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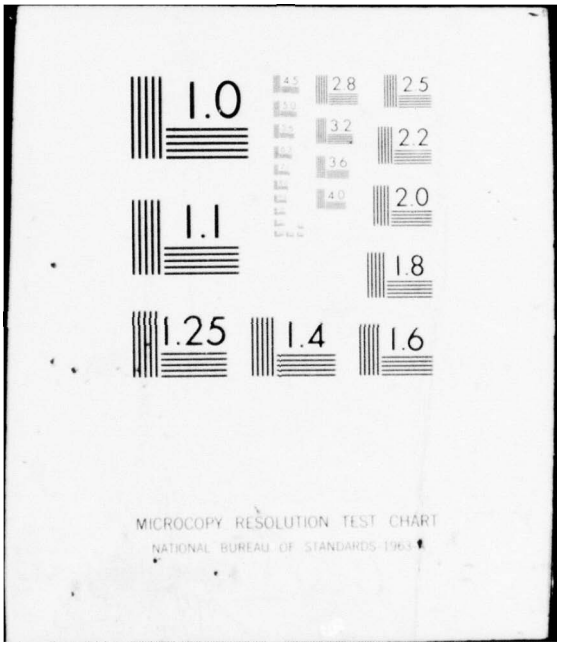
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DCIEM Technical Report No. 76-X-69

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DEPARTMENT OF NATIONAL DEFENCE — CANADA

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DEPARTMENT OF NATIONAL DEFENCE - CANADA

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ABSTRACT

This report presents the results of an investigation conducted at Kingston, Ontario to determine the effect of a new car-ferry service upon ambient noise levels in the two Canadian Forces Colleges housed in nearby Fort Frontenac.

By means of questionnaires and computed Noise Pollution Levels, it was concluded that annoyance and sleep disturbance were a problem in quarters close to the ferry dock.

It is recommended that the ferry should not sound its horn prior to departure from its dock next to Fort Frontenac. This, alone, would eliminate the most serious source of annoyance and disturbance. Also, the Fort Frontenac Library, and rooms in the Bradstreet Block with windows facing east and south, should be fitted with sealed, double-glazed, noise-attenuating windows, and be equipped with air-conditioning.

INTRODUCTION

Fort Frontenac, situated on the Cataraqui River, Kingston, Ontario, is the home of the National Defence College (NDC) and the Canadian Land Forces Command and Staff College (CLFCSC). For many years, the highest level of academic and professional training has been provided at these colleges to members of the Canadian Forces and selected civilian representatives of the Defence and other government departments.

In September 1975, an intergovernmental agreement permitted the Ministry of Transportation and Communications of the Province of Ontario (MTCO) to relocate its Wolfe Island ferry service[1] from the foot of Brock Street to the foot of Barrack Street on the southern perimeter of Fort Frontenac (designated NFD (new ferry dock) in Figure 1). As a result, vehicles from a 55-car ferry began to embark and disembark within approximately 200 feet of the Bradstreet Block (which houses the colleges' library and some sleeping accommodations) and to enter and exit to and from the ferry-dock car-park area to Ontario Street (Highway No. 2) within 25 feet of the south end of the Bradstreet and De Noyan Blocks (see Figures 2 to 5).

During discussions prior to the commencement of construction of the new ferry dock, it was acknowledged by MTCO and DND officials that "routine ferry operations would unacceptably interfere with operation of the library and study-living quarters at Fort Frontenac". Further, "intergovernmental agreement (would) include for provision of necessary sound abatement solution funded by MTCO or as arranged between MTCO and MND (DND)"[2].

It was necessary, however, that DND determine the effect of the new ferry service upon the ambient noise levels at critical areas within Fort Frontenac. Since such an investigation was beyond the technical expertise and resources of CFB Kingston and/or Air Transport Command HQ (6665-9 (SSO Surg), 28 October 1974), the Sonics Section of DCIEM was tasked to carry out the necessary studies (6665-9 (DPM 4), 13 November 1974).

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[1] Daily ferry service is provided by MTCO about every 1 hour and 20 minutes, starting at 0615 AM until 0200 AM, for vehicles travelling between Kingston and Wolfe Island.

[2] From letter 7625-2027 (CE), para 5d, CFB Kingston, dated 21 February 1974.

It was decided that such studies should take place during the summer months when windows in the Fort Frontenac study/living quarters would normally be open (in the absence of air conditioning) and their occupants most affected by noise from ferry operations.

Three buildings were considered to be susceptible to noise disturbance:

1. The Bradstreet Block, housing the colleges' library and study/living quarters,

2. The De Noyan Block, and

3. The La Salle Block, containing the Fort Frontenac Officers' Mess (see Figure 1).

However, since the sleeping quarters in the La Salle Block were fitted with window air-conditioning units, it was deemed unlikely that noise from the new ferry dock would cause disturbance in this building. Therefore, noise studies were restricted to the Bradstreet and De Noyan Blocks.

During the period May-September, 1975, the only week in the CLFSCS calendar that permitted 24-hour access to the rooms in these buildings (without disturbing students) was June 16 to 19th. During this week, then, as weather conditions allowed[3], noise-level recordings were made in Rooms 215, 225 and the library of the Bradstreet Block, and in Rooms 2B and 21 of the De Noyan Block (see Appendix A for recording procedures). Again during the week of June 14 to 18th, 1976, as weather permitted, recordings were made in Rooms 225, 303, 304 and 320 of the Bradstreet Block and in Room 21 of the De Noyan Block. The majority of the recordings were made between 2200 at night and 0715 in the morning, the period considered most critical for possible study and sleep-interference problems.

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[3] No rain or thunder, and wind velocity not greater than 10 mph.

FINDINGS

Qualitative Analyses of Ambient Noise Levels - In general, the prevailing night-time ambient noise observed at Fort Frontenac, at least for the two one-week periods during which recordings were made in June of 1975 and 1976, may be characterized as follows:

1. Late evening to about 0200 AM.

Between 2200 and about 0200, noise in the area of Fort Frontenac resulted primarily from moderately steady road traffic, with occasional stopping and starting. The west side of the De Noyan Block is closest to these sources, and in Room 21 noise levels fluctuated typically between about 48 and 60 dBA[4]. Occasional peaks exceeded 70 dBA, due to screeching tires, car horns, and large trucks accelerating in low gears[5] (see Figure 8).

Along the front of the Fort is a stone wall (see Figure 2) which is approximately 12 feet in height and 24 feet from the west side of the De Noyan Block. It reduced the noise produced by traffic on Ontario Street, at the windows of first floor rooms in the building (e.g. Room 2B), by about 10 dB relative to the levels observed in second floor windows overlooking the street.

In rooms further away from Ontario Street, traffic noise was less intense, varying typically between 45 and 55 dBA (with random peaks above 60 dBA) in west- and south-facing windows in the Bradstreet Block, and between 45 and 50 dBA in east-facing windows.

2. Between 0200 and 0600 AM.

During this period, road traffic in the centre of Kingston was intermittent, permitting ambient noise levels

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[4] See foot-note to Appendix A for definition of dBA.

[5] Up to about 2330 at night and between 0600 and 0700 in the morning, the noise from revving bus engines in the Kingston Public Transit Garages on the west side of Ontario Street (see Figure 4) is a major source of disturbance to occupants of rooms overlooking the street.

to drop to between 40 and 45 dBA (for no-wind conditions) for intervals frequently as long as two to three minutes. The noise produced by vehicles passing over the metal gratings on the La Salle Causeway (see Figures 10 to 12), 200 yards to the north of the De Noyan Block, was one of the more audible sounds during these 'quiet' periods.

The sounds of nature can be significant during low ambient-noise periods (Wesler, 1973). It can be seen in Figure 11, for example, that the early morning songs of birds in nearby trees resulted in sound pressure levels as high as 58 dBA at the window of Room B303. Such sounds can interfere with sleep if individuals are not used to them.

3. After 0600 AM.

After about 0600, a gradual increase in the ambient noise level occured as traffic and general activity in the city picked up. The activities of maintenance personnel and garbage collections within Fort Frontenac were frequent sources of early morning noise.

Not surprisingly, the noise resulting from car-ferry operations was most evident in rooms on the east side of the Bradstreet Block. A typical noise time-history (Figure 10), recorded in the window of Room 303 between 0130 and 0215 on June 17th, depicts most dramatically the arrival and departure of the ferry.

Prior to its arrival at about 0140, the ambient noise level was fluctuating between 45 and 48 dBA, with traffic on the La Salle Causeway (Figure 10, (a)) producing peaks to 54 dBA. As the ferry approached, a public address loudspeaker[6] and general activity on the dock (b,c) resulted in peaks to 64 dBA, the dropping of the loading ramp (d), a peak of 71 dBA (see Figures 13 and 14), and vehicle horns and screeching tires (e,f), peaks from 65 to 68 dBA. While the ferry was berthed, the ambient level fluctuated from 57 to 60 dBA. Before the ferry departed

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[6] The dock public address system did not appear to be used routinely, but rather for occasional dock-side announcements.

at 0205, a blast from its horn (g) produced a peak of 83 dBA[7], and once underway, the ferry's engines raised the ambient noise level briefly to 62 dBA.

A similar noise time-history is shown in Figure 11, recorded later in the morning (0545 to 0630) at the same location. In this instance the ferry remained in dock for eight minutes and departed without sounding its horn.

On the south side of the Bradstreet Block overlooking the approach to the car-park area (Figure 4), noise from ferry operations was noticeable (at the south window of Room 225). Peak levels due to the ramp dropping (Figure 9.1, (a)) and vehicle horns on the dock (b) were 70 and 76 dBA respectively, and the blast from the ferry horn produced a level of 83 dBA inside the room. The ambient level while the ferry was berthed (Figure 15) fluctuated between 52 and 56 dBA on this side of the building.

Noise from ferry operations was much less evident in rooms on the west side of the Bradstreet Block. In Room 320, the noise of the ramp dropping was 60 dBA (Figure 9.2, (a)) and car horns on the dock (b) produced levels between 64 and 69 dBA. In Room 304 towards the north end of the building, only the occasional noise from tires (Figure 10, (f)) and the blast from the ferry horn (g) (75 dBA) were audible.

On the west side of the De Noyan Block where traffic noise was louder, the blast from the ferry horn (Figure 8, (c)) (80 dBA) was the only sound that could be noticed from the dock.

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[7] The blast from the car-ferry horn is shown in Figure 10 to be 77 dBA. Other measurements indicated that the horn blasts on these recordings (Figures 8 to 11) were being limited in the recorder amplifiers, and that when the amplifier gains were reduced appropriately, the sound pressure levels produced by the horn (inside the rooms) actually reached levels of 83 dBA in B303 and B225, 80 dBA in D21 and D22, 75 dBA in B320 and 65 dBA in B225 with both windows closed.

Noise Pollution Levels - In general, the higher the level of a noise (of given spectrum), the more disturbance it will create[8]; the less steady the level of a noise, the greater its distracting and hence annoying quality (Robinson, 1971).

Many researchers have thus concluded that in assessing noise annoyance or disturbance, one should take into account not only the average (frequency weighted) intensity of the noise, but also some measure of its variability (Anon, 1976).

Robinson derived a unified noise nuisance index (termed Noise Pollution Level, L_{NP}), based on social survey data for traffic and aircraft noise (Griffiths and Langden, 1968; McKennel, 1963), that was intended to apply for all sources.

Noise Pollution Level is given by

$$L_{NP} = L_{eq} + k.\sigma,$$

where L_{eq} is the 'energy equivalent' of the noise (measured in dBA, PNdB, or some other frequency weighting) over a specified period, σ is the standard deviation of the instantaneous level considered as a statistical time series over the same time period, and k is a constant provisionally assigned the value of 2.56.

The energy equivalent noise level, L_{eq}, for a specified period is the level of a constant or steady-state noise which has an amount of acoustic energy equivalent to that contained in the measured noise. Leq is calculated from amplitude (probability) distributions of traffic and community noise (see Appendix A) using the equation

$$L_{eq} = 10 \log_{10} \left[\frac{1}{100} \sum f_i 10^{L_i/10}\right]$$

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[8] This is true within limits. Robinson points out that "too low an ambient noise level may result in a lack of privacy or inordinate sensitivity of harmless sounds which would otherwise be masked off" (Ref 15).

where L_i = sound pressure level in dBA corresponding to the class mid-point of class i,

f_i = time interval (expressed as a percentage of the relevant time period) for which the sound pressure level is within the limits of class i (ISO, 1970).

In this investigation, Noise Pollution Levels were computed for each 10-minute period[9] during which recordings were made at Fort Frontenac. The resulting values of L_{NP}, L_{eq} and σ are listed in Appendix B.

Figures 16 to 18 show time histories of L_{NP} for the noises recorded at the windows of Rooms 303 and 225 in the Bradstreet Block. The horizontal bars at the bottom of the figures indicate periods when the ferry was berthed at the new dock; A, D, and H signify arrivals, departures and whether the ferry horn was sounded.

It can be seen that L_{NP} increased significantly during these periods. Whereas it ranged from 49 to 58 dBA during the 'quiet periods' between 2300 and 0600, L_{NP} increased to between 60 and 88 dBA while the ferry was at dockside. It is noted that on the two occasions when the horn was not sounded upon departure of the ferry (0045 and 0620, Figure 16), L_{NP} was reduced considerably. Note also that the ferry made an extra early morning run at 0500 on June 18th (Figures 17 and 18).

Time histories of L_{NP} are shown in Figures 19 and 20 for Rooms 215 and 225, computed from noise recorded in June 1975 prior to the inauguration of ferry service from the new dock. On the east side of the Bradstreet Block (Figure 19), no extraordinary peaks occured in L_{NP}. Slight variations in L_{NP} were noted at the south window of Room 225 (Figure 20), particularly after about 0450, due to traffic noise from nearby streets to the south west.

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[9] It was hoped that employing as short time-periods as practical would give reasonably homogeneous noise events within each interval. During car-ferry arrivals and departures, of course, such homogeneity was not possible, unless the arrival or departure occured close to the beginning or end of a given 10-minute interval.

A time history of L_{NP}, computed from noise recorded inside Room 225 with the east window open, is shown in Figure 21. Here, the quiescent values of L_{NP} for the background noise in the room (34 to 41 dBA) were separated by values 20 to 34 dB higher, corresponding in time to the arrivals and departures of the ferry.

It can be seen from Figures 22 and 23 that on the west side of the Bradstreet Block, L_{NP} was affected to a far less extent by noise from the new dock. As with the analogue time-histories (Figures 9.2 and 10.2), the most discernible indications of ferry operations on this side of the building were the blasts from the ferry horn.

Time histories of L_{NP} for noise recorded at the window of Room 21 of the De Noyan Block in 1975 and 1976 are shown in Figures 24 and 25. No clear effect due to ferry operations was noticeable (Figure 24), although one might have expected L_{NP} to increase to about 70 dBA if the ferry horn had been sounded upon departure at 0045. Certainly, it was not possible (with the limited data available) to determine whether traffic noise had increased significantly at this location between 1975 and 1976.

Noise Disturbance - The question now to be answered is what relationship is there between Noise Pollution Level and annoyance or disturbance[10]. Langdon (1976a) has shown that although L_{NP} correlates well with noise annoyance[11] due to non-free flowing traffic, the relationship does not permit the accurate prediction of individual dissatisfaction. For one thing, the degree of dissatisfaction observed at a given noise level may be influenced by factors other than noise, notably by the perceived quality of the local neighbourhood (Aubree, 1971; Langdon, 1976b).

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[10] Annoyance (after Borsky, 1972) may be defined as a feeling of displeasure associated with any agent or condition realized or believed by an individual to be adversely affecting him. Its effect on activity can be negative (e.g., if distraction results) or positive (if arousal occurs and improves performance), and may habituate with continued exposure. Disturbance may be considered as interference with activity such as listening to conversation or falling and staying asleep, and for these effects adaptation does not usually occur.

[11] As rated by neighbourhood residents on a seven-point semantic differential scale from "definitely satisfactory" to "definitely unsatisfactory".

Robinson (1971) has estimated, however, that 50 per cent of annoyance[12] for aircraft noise (McKennell, 1963) and freely flowing traffic (Griffiths and Langdon, 1968) corresponds approximately to L_{NP} = 80 dBA (computed over 24 hours), well above the values observed inside rooms on the east side of the Bradstreet Block overlooking the ferry dock (see Figure 21). It is doubtful whether this "threshold of annoyance" level is valid in the present situation, given that the exposed population at Fort Frontenac is comprised of military students, and the values of L_{NP} reported herein were derived exclusively from night-time noise levels.

Moreover, Langdon (1976a) and Aubree (1971) have shown that sleep disturbance (the most critical concern of this study) is on a dimension entirely different from day-time noise disturbance, and is not related to a person's general dissatisfaction with his environment. A great many variables affect an individuals responsiveness to noise during sleep (Lukas, 1976). Sleep disturbance generally increases with age, length of time asleep, sleep stage, stressful presleep state, intensity and duration of the noise stimulus, etc. It appears, however, that sleep disturbance is unlikely to occur if indoor noise levels L_{eq} remain below 70 EPNdB (57 dBA). When occasional noise peaks reach 90 EPNdB (77 dBA) they will probably evoke at least a change in sleep stage in about 50 per cent of the people exposed (Lukas, 1975).

It is noted that the night-time ambient noise levels (L_{eq}) inside the rooms of the Bradstreet and De Noyan Blocks ranged between 32 and 35 dBA. In rooms on the east side of the Bradstreet Block, however, noise from activity on the ferry dock (e.g., ramp dropping, horns honking) produced occasional peaks to 50 dBA, and the blast of the ferry horn resulted in levels between 75 and 83 dBA (see footnote 7).

Reaction of Individuals to Noise At Fort Frontenac - In conjunction with the DCIEM investigation, the Administrative Officer, CLFCSC, solicited comments (see Appendix C) from 70 course officers (30 quartered in the Bradstreet Block, 40 in the De Noyan Block, during the four month period between January and May 1976) concerning possible noise nuisance resulting from the new ferry service. The responses received from 33 individuals are summarized in Table I.

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[12] The point at which speech conversation begins to be disrupted and windows are better left closed for enjoyment of radio and television (Langdon, 1976b).

TABLE I

SUMMARY OF NOISE SURVEY RESPONSES AT FORT FRONTENAC

	East Side of Bradstreet Block, Rooms Facing New Ferry Dock	West Side of Bradstreet Block, Rooms Facing Parade Square	East Side of De Noyan Block, Rooms Facing Parade Square	West Side of De Noyan Block, Rooms Facing Ontario Street
Number of Responses	11	7	8	7
Noise did not cause annoyance or disturbance	5	4	7	7
Noise was a source of annoyance or disturbance	2	1	1	
Noise disturbed sleep	2			
Noise Sources Mentioned				
Due to ferry operations				
Ferry horn	10	3	5	1
Dock PA system	3	2		
Voices on dock	2	1		
Loading ramp dropped	1		1	
Car horns on dock	2			
Not due to ferry operations				
Garbage collection, snow removal or pavement sweeper in Fort Frontenac	2	2	1	1
Cars crossing La Salle Causeway	2			
Radio/PA from Police Station		1		
Noise from Bus Garage				1
Street traffic	1	1		1

Of the six persons who considered noise to be annoying, four (including the two who reported significant sleep disturbance) occupied rooms on the east side (facing the ferry dock) of the Bradstreet Block. None of the six were on the west side (facing Ontario Street) of the De Noyan Block.

Eighteen of the 23 who did not consider noise to be an annoyance were located on the west side of the Bradstreet Block or in the De Noyan Block. On the other hand, five of the 11 respondents occupying rooms facing the ferry dock were not dissatisfied with the noise.

It should be noted, however, that sensitivity to noise, not noise exposure itself, is considered the most important determinant of annoyance (Bryan, 1974). Noise-exposed populations are not homogeneous[13] and the more sensitive individuals tend to show higher initial annoyance, and a less steep growth of annoyance with noise level, than do insensitive persons. This initial difference is most marked in the range from 55 to 60 dBA (in rooms overlooking the dock, the ferry horn blast ranges from 75 to 83 dBA) and tends to disappear at about 90 dBA; above this level nearly everyone is annoyed (Moreira and Bryan, 1972).

Clearly, the blast of the ferry horn was the most objectionable noise emanating from the new dock, especially for persons living in the Bradstreet Block[14]. Nineteen of the 33 respondents mentioned this source of disturbance in their replies. Other annoyances included the dock public-address system, car horns, loud voices and the dropping of the ferry loading ramp.

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[13] In a study by Langdon (1976a), a simple self-rating scheme (respondents were asked to identify with either or neither of two statements: "I am very sensitive to noise", or "Noise never bothers me at all") showed that 29 per cent of the residents polled were sensitive to noise, 31 per cent were neutral, and 40 per cent were non-sensitive. Langdon noted, however, that the more noise-sensitive individuals probably tended to avoid or move away from noisy neighbourhoods.

[14] When close to the ferry (e.g., on the patio of the Officers' Mess or in rooms overlooking the dock), the author's initial reaction to blasts from the ferry horn was a startle.

Interestingly, noises not connected with the ferry were also mentioned as frequent sources of annoyance. Among these were early-morning and late-night garbage collection, snow removal and pavement sweeping activities within Fort Frontenac, vehicles driving over the metal gratings on the La Salle Causeway, engines revving at the Kingston Public Transit System Garage, and police car radios outside the Station on the west side of Ontario Street.

Noise Disturbance in the Fort Frontenac Library - The Fort Frontenac library is situated in the basement and on the ground floor at the south end of the Bradstreet Block (see Figure 1). Its proximity to the new ferry dock makes the library particularly vulnerable to noise disturbance.

During the summer, the south and east windows of the library must be open for fresh air (see Figures 26 and 27). Additional air circulation is obtained during hot weather from a 174 hp fan, placed on the bookcase in the general reading room (Figure 28).

With the fan running, the ambient noise levels at L_1, L_2, L_3, and L_4 in the general reading room (see Figure 26) were 59, 60, 59 and 56 dBA respectively (in the absence of noise from the ferry dock), very much in excess of levels (38 to 47 dBA) recommended for library background noise (Beranek, 1971). As unacceptable as these levels were, however, the noise of the fan did serve to mask a great many of the sounds emanating from the ferry dock (the library windows being open) that would otherwise have caused distraction. Even so, the ferry horn remained the major source of disturbance, producing a level of 83 dBA. In the basement section of the library, moreover, exhaust fumes from vehicles driving in and out of the dock parking area were an added source of irritation.

When the library windows were closed and the fan not running, the ambient noise level in the general reading area was 36 dBA. The ferry horn remained most disturbing, producing a level of 65 dBA.

CONCLUSIONS

1. The blast produced by the ferry horn is clearly the most objectionable and disturbing aspect of operations at the new MTCO dock at the foot of Barrack Street. When room windows in Fort Frontenac are open, interior sound pressure levels from this source range from 75 to 83 dBA, depending on the location of the room relative to the dock. Even when windows are closed, the noise level inside rooms overlooking the dock is 65 dBA. During Summer months when windows must be open (in the absence of air conditioning), the noise from the ferry horn undoubtedly disturbs sleep, at the very least producing changes in the level of sleep, in probably more than half of the individuals thus exposed.

2. Aside from the horn blasts, ambient noise levels at the Bradstreet Block room windows overlooking the dock area and the Cataraqui River increase on the average from 46 to 58 dBA when the ferry's engine is idling at dockside. Additional noise peaks, up to about 70 dBA, occur when the ferry loading ramp is dropped, car horns are honked, or announcements are broadcast over the dock-area public address system.

   Inside these rooms, the quiescent night-time Noise Pollution Level, L_{NP}, ranges from 34 to 41 dBA. When the ferry is berthed at the dock, L_{NP} increased typically to between 40 and 54 dBA, neglecting the horn blasts.

   Most people are probably not bothered by these noises. Perhaps 20 per cent of the individuals (those most annoyed by noise) quartered in these rooms, however, find the noise emanating from the new ferry dock objectionable and a source of disturbance.

3. In rooms in the Bradstreet Block not overlooking the dock area and Cataraqui River, and in rooms in the De Noyan Block where noise produced by traffic on nearby streets is louder, noise from the dock (except for the ferry horn) is generally not the major source of annoyance. More disturbing are the noises created by early-morning and late-night garbage collections and snow removals within Fort Frontenac, and noise emanating from the Kingston Public Transit System Garage and the Police Station on the west side of Ontario Street.

4. During the summer, the windows of the Fort Frontenac Library must be open (in the absence of air conditioning) for fresh air. Additional air circulation is obtained from a fan placed on a bookcase in the general reading room.

With the fan running, the ambient noise in the reading room is unacceptably high, but serves to mask many of the sounds emanating from the ferry dock that would otherwise cause distraction and annoyance. Even so, the ferry horn is a particular source of disturbance to persons working in the library.

RECOMMENDATIONS

1. The Wolfe Island Ferry should not sound its horn prior to departure from the new Barrack Street dock. This alone would eliminate the most serious source of annoyance and disturbance to residents at Fort Frontenac.

2. The Fort Frontenac Library, and rooms in the Bradstreet Block with windows facing east and south, should be fitted with sealed, double-glazed, noise-attenuating windows, and be equipped with air conditioning. This assumes, of course, that noise from the air conditioning unit is not in itself a source of annoyance. If regulations require the ferry to sound its horn before departure, all rooms in the Bradstreet Block, and those in the De Noyan Block facing east, should be sealed and air conditioned as specified above.

ACKNOWLEDGMENTS

The author wishes to thank the Commandant, Canadian Land Forces Command and Staff College, for the cooperation extended to him by the staff of Fort Frontenac during this investigation.

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APPENDIX A

NOISE MEASUREMENT AND ANALYSIS PROCEDURES

A-weighted* sound-pressure level recordings were made in this investigation using Nagra IV-S and IV-SJ analogue tape recorders and Bruel and Njaer 2203 and 2209 Precision Sound Level Meters. Acoustical and electrical signals were calibrated with a Bruel and Kjaer 4220 Pistonphone.

Except where specified, the recording microphone was placed on the inside sill of the sliding (hung) sash window (bottom half of the window was three-quarters open) of the room under study, with the microphone's zero-degree axis normal to the window and with its diaphragm face approximately six inches behind (inside the room) the plane of the lower windowpane.

In certain rooms (e.g., B225) a glass deflector, mounted on the inside sill at an angle of about 30 degrees to the window, was removed to facilitate the above microphone placement. When recordings were made inside Room B225, the deflector was replaced.

From these recordings, graphical time histories (Figures 8 to 11) were produced as required using a Bruel and Kjaer 2305 Level Recorder having a 50-dB potentiometer range. In addition, statistical distribution analyses were performed on all recordings with a Bruel and Kjaer 4420 Analyzer (sampling rate = 10 Hz) in conjunction with the 2305 Level Recorder (potentiometer range = 25 dB, lower limiting frequency = 20 Hz, writing speed = 200 mm/sec, rectifier = true RMS).

The probability distribution of the noise levels observed in a given 10-minute period (using 2.5-dB intensity (class) intervals) was then employed to compute the value of L_{eq}, σ and L_{NP} for that 10-minute time period (see Appendix B).

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* A sound having energy that is concentrated in the 20 to 500-Hz range produces a sensation that is less loud than a sound with an equal amount of energy in the frequency range from 500 to 5000 Hz. Thus, when an estimate of the loudness of a sound is required, its low-frequency components are de-emphasized. One particular frequency weighting, the A-weighting, applies approximately 30 dB of de-emphasis at 50 Hz, and decreases to 5 dB at 500 Hz and 0 dB at 1000 Hz. Sound pressure levels that are so weighted are expressed as dBA.

APPENDIX B

COMPUTED VALUES OF L_{eq}, σ and L_{NP} FOR THE NOISE LEVELS OBSERVED OVER 10-MINUTE TIME PERIODS AT SPECIFIED LOCATIONS AT FORT FRONTENAC

TABLE B1

Room 303, Bradstreet Block. June 16-17, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310	48	0.9	51
2210-2220				0310-0320	47	1.5	51
2220-2230	47	1.3	50	0320-0330	46	1.1	49
2230-2240	50	1.5	54	0330-0340	46	1.3	50
2240-2250	50	1.5	53	0340-0350	47	1.4	50
2250-2300	52	1.6	56	0350-0400	47	1.9	52
2300-2310	58	1.2	61	0400-0410	47	1.5	51
2310-2320	66	2.0	72	0410-0420	46	1.1	49
2320-2330	52	3.4	61	0420-0430	47	1.5	51
2330-2340	49	1.5	53	0430-0440	47	1.9	52
2340-2350	52	1.3	55	0440-0450	47	1.8	52
2350-2400	51	2.2	57	0450-0500	47	1.8	52
0000-0010	51	2.8	59	0500-0510	48	1.8	52
0010-0020	51	2.5	58	0510-0520	47	1.5	51
0020-0030	57	3.0	65	0520-0530	49	1.5	53
0030-0040	58	0.7	60	0530-0540	47	1.4	50
0040-0050	55	4.6	67	0540-0550	49	1.7	54
0050-0100	50	2.2	56	0550-0600	50	1.7	54
0100-0110	47	1.7	52	0600-0610	54	1.4	57
0110-0120	48	1.7	52	0610-0620	60	2.3	66
0120-0130	48	1.8	53	0620-0630	50	1.7	54
0130-0140	47	1.7	52	0630-0640	50	1.7	55
0140-0150	57	3.8	66	0640-0650			
0150-0200	59	0.7	60	0650-0700			
0200-0210	64	5.9	79	0700-0710			
0210-0220	46	1.1	49	0710-0720			
0220-0230	47	1.3	50	0720-0730			
0230-0240				0730-0740			
0240-0250	47	1.5	51	0740-0750			
0250-0300	48	1.5	52	0750-0800			

TABLE B2

22 Room 225 (east window), Bradstreet Block. June 17-18, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220				0310-0320			
2220-2230				0320-0330	46	2.3	52
2230-2240	50	2.2	56	0330-0340	44	1.8	49
2240-2250	51	2.4	57	0340-0350	44	1.5	48
2250-2300	50	2.4	56	0350-0400	46	2.2	51
2300-2310	59	1.7	63	0400-0410	45	2.1	50
2310-2320	58	1.1	61	0410-0420	44	2.1	49
2320-2330	66	5.3	79	0420-0430	44	2.1	49
2330-2340	48	2.4	54	0430-0440	44	2.3	50
2340-2350	48	2.6	54	0440-0450	45	2.2	51
2350-2400	49	2.9	56	0450-0500	49	2.8	56
0000-0010	48	2.9	56	0500-0510	58	1.9	63
0010-0020	50	3.4	59	0510-0520	69	7.4	88
0020-0030	59	4.0	70	0520-0530	46	1.8	50
0030-0040	65	1.7	70	0530-0540	47	2.2	52
0040-0050	53	5.8	68	0540-0550	48	2.4	54
0050-0100	45	2.2	51	0550-0600	47	2.3	53
0100-0110	46	2.3	52	0600-0610	57	5.3	70
0110-0120	47	2.4	53	0610-0620	65	6.4	82
0120-0130	49	3.5	58	0620-0630	49	2.9	57
0130-0140	47	1.9	52	0630-0640	49	2.2	55
0140-0150	57	2.8	65	0640-0650	54	4.1	64
0150-0200	65	1.6	69	0650-0700	51	2.5	57
0200-0210	53	4.9	66	0700-0710	59	5.1	72
0210-0220	47	1.8	52	0710-0720	67	5.3	80
0220-0230	46	1.5	50	0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B3

Room 225 (south window), Bradstreet Block. June 17-18, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220				0310-0320			
2220-2230				0320-0330	49	3.1	57
2230-2240	54	2.8	61	0330-0340	46	1.0	49
2240-2250	55	3.5	64	0340-0350	47	1.6	51
2250-2300	53	2.5	60	0350-0400	49	2.6	55
2300-2310	58	2.8	65	0400-0410	50	3.3	58
2310-2320	56	2.5	63	0410-0420	48	2.8	55
2320-2330	66	4.1	77	0420-0430	47	2.3	53
2330-2340	53	3.6	62	0430-0440	49	3.0	57
2340-2350	53	3.7	62	0440-0450	47	2.3	53
2350-2400	52	3.4	60	0450-0500	51	2.8	58
0000-0010	53	3.8	62	0500-0510	54	2.2	60
0010-0020	53	3.7	62	0510-0520	69	5.5	83
0020-0030	58	5.2	72	0520-0530	50	2.4	57
0030-0040	55	1.8	59	0530-0540	51	2.7	58
0040-0050	65	4.2	75	0540-0550	53	3.7	62
0050-0100	49	3.0	57	0550-0600	50	2.9	57
0100-0110	50	3.0	58	0600-0610	54	4.3	65
0110-0120	51	3.2	59	0610-0620	65	3.5	74
0120-0130	55	4.7	67	0620-0630	55	4.3	66
0130-0140	50	3.0	58	0630-0640	53	3.8	63
0140-0150	54	3.2	62	0640-0650	55	4.1	65
0150-0200	55	1.9	60	0650-0700	53	3.6	62
0200-0210	69	4.5	81	0700-0710	58	4.8	71
0210-0220	48	2.5	54	0710-0720	66	4.4	78
0220-0230	48	2.2	53	0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B4

24 Room 225 (south window), Bradstreet Block. June 18-19, 1975.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220				0310-0320			
2220-2230				0320-0330			
2230-2240				0330-0340			
2240-2250				0340-0350			
2250-2300				0350-0400			
2300-2310	54	3.7	64	0400-0410			
2310-2320	54	4.0	65	0410-0420	46	1.2	49
2320-2330	54	3.7	64	0420-0430	46	2.4	52
2330-2340	52	3.7	62	0430-0440	47	2.7	53
2340-2350	53	3.5	62	0440-0450	46	1.7	51
2350-2400	52	3.8	62	0450-0500	52	3.9	62
0000-0010	51	4.0	62	0500-0510	47	2.2	53
0010-0020	51	4.0	62	0510-0520	47	2.1	53
0020-0030	51	3.6	60	0520-0530	51	3.5	60
0030-0040	52	3.7	61	0530-0540	50	2.7	56
0040-0050	52	3.8	61	0540-0550	54	4.5	66
0050-0100	50	3.1	58	0550-0600	51	3.0	59
0100-0110	51	3.7	60	0600-0610	53	3.9	63
0110-0120	51	3.3	60	0610-0620			
0120-0130	51	3.5	60	0620-0630			
0130-0140	50	3.1	58	0630-0640			
0140-0150	49	2.4	55	0640-0650			
0150-0200	50	3.3	58	0650-0700			
0200-0210	49	2.7	56	0700-0710			
0210-0220				0710-0720			
0220-0230				0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B5

Room 215, Bradstreet Block. June 18-19, 1975.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220				0310-0320			
2220-2230				0320-0330			
2230-2240				0330-0340			
2240-2250				0340-0350			
2250-2300				0350-0400			
2300-2310				0400-0410			
2310-2320				0410-0420	45	1.6	50
2320-2330				0420-0430	46	1.7	51
2330-2340	48	2.7	55	0430-0440	46	1.5	50
2340-2350	48	2.7	55	0440-0450	47	2.1	52
2350-2400	48	3.0	56	0450-0500	47	2.4	53
0000-0010	47	2.6	53	0500-0510	46	1.7	50
0010-0020	47	2.8	54	0510-0520	47	2.1	52
0020-0030	47	2.4	53	0520-0530	47	1.9	52
0030-0040	47	2.6	54	0530-0540	47	2.3	53
0040-0050	47	2.7	54	0540-0550	48	2.4	54
0050-0100	46	2.2	52	0550-0600	49	2.6	55
0100-0110	47	2.4	53	0600-0610	49	2.8	56
0110-0120	48	2.3	54	0610-0620	48	2.4	54
0120-0130	46	2.2	52	0620-0630	47	2.9	54
0130-0140	46	2.4	53	0630-0640			
0140-0150	47	2.1	52	0640-0650			
0150-0200	46	1.8	50	0650-0700			
0200-0210	47	2.1	52	0700-0710			
0210-0220				0710-0720			
0220-0230				0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B6

Room 225 (interior), Bradstreet Block. June 14-15, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310	33	1.0	35
2210-2220				0310-0320	33	0.9	35
2220-2230				0320-0330	33	1.3	36
2230-2240				0330-0340	33	1.1	35
2240-2250	35	1.8	40	0340-0350	32	0.6	34
2250-2300	34	1.3	38	0350-0400	33	0.7	34
2300-2310	42	4.6	54	0400-0410	33	1.7	38
2310-2320	44	1.4	47	0410-0420	33	0.8	35
2320-2330	60	5.2	74	0420-0430	33	0.8	35
2330-2340	35	1.8	39	0430-0440	33	0.9	35
2340-2350	35	1.9	39	0440-0450	32	0.7	34
2350-2400	34	1.6	38	0450-0500	33	1.4	37
0000-0010	34	1.6	38	0500-0510	33	1.1	36
0010-0020	33	1.5	37	0510-0520	33	1.1	36
0020-0030	39	4.1	50	0520-0530	32	0.6	34
0030-0040	43	1.1	46	0530-0540	33	1.2	36
0040-0050	56	5.4	70	0540-0550	34	2.1	39
0050-0100	33	1.1	36	0550-0600	33	1.4	37
0100-0110	33	1.3	36	0600-0610	38	3.4	46
0110-0120	33	1.1	36	0610-0620	43	3.9	53
0120-0130	33	1.5	37	0620-0630	35	2.3	41
0130-0140	34	1.6	38	0630-0640	34	2.0	39
0140-0150	41	3.0	48	0640-0650			
0150-0200	42	1.5	45	0650-0700			
0200-0210	57	4.4	69	0700-0710			
0210-0220	33	1.2	36	0710-0720			
0220-0230	33	1.5	37	0720-0730			
0230-0240	33	1.3	36	0730-0740			
0240-0250				0740-0750			
0250-0300	33	0.7	34	0750-0800			

TABLE B7

Room 304, Bradstreet Block. June 16-17, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310	45	1.7	49
2210-2220				0310-0320	45	2.0	51
2220-2230				0320-0330	47	3.2	56
2230-2240	50	2.0	55	0330-0340	45	2.0	50
2240-2250	49	1.8	54	0340-0350	44	1.1	47
2250-2300	50	2.2	56	0350-0400	45	2.3	51
2300-2310	51	1.9	56	0400-0410	44	1.4	47
2310-2320	59	2.3	65	0410-0420	45	1.5	48
2320-2330	50	2.0	55	0420-0430	44	1.2	47
2330-2340	49	1.7	54	0430-0440	45	1.6	49
2340-2350	50	1.9	55	0440-0450	45	1.8	50
2350-2400	49	1.9	54	0450-0500	47	2.5	54
0000-0010	49	1.8	53	0500-0510	47	2.0	52
0010-0020	49	2.0	54	0510-0520	47	1.6	51
0020-0030	49	1.8	54	0520-0530	48	1.8	53
0030-0040	49	1.7	53	0530-0540	49	2.1	54
0040-0050	48	2.0	53	0540-0550	50	2.3	56
0050-0100	50	3.1	58	0550-0600	50	1.7	54
0100-0110	48	1.7	52	0600-0610	51	1.9	56
0110-0120	50	2.3	56	0610-0620	52	3.3	61
0120-0130	50	2.6	57	0620-0630	46	1.9	51
0130-0140	50	2.4	56	0630-0640	49	2.0	55
0140-0150	51	2.2	56	0640-0650			
0150-0200	50	2.4	57	0650-0700			
0200-0210	58	3.2	66	0700-0710			
0210-0220	46	1.1	49	0710-0720			
0220-0230	46	1.4	50	0720-0730			
0230-0240				0730-0740			
0240-0250	49	2.4	55	0740-0750			
0250-0300	47	2.1	53	0750-0800			

TABLE B8

28 Room 320, Bradstreet Block. June 17-18, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210	56	2.4	62	0300-0310			
2210-2220	54	2.9	62	0310-0320			
2220-2230	55	2.8	62	0320-0330			
2230-2240	52	2.7	59	0330-0340			
2240-2250	55	3.3	63	0340-0350			
2250-2300	51	2.0	56	0350-0400			
2300-2310	55	3.1	63	0400-0410			
2310-2320	57	3.2	65	0410-0420			
2320-2330				0420-0430			
2330-2340	51	2.7	58	0430-0440			
2340-2350	51	2.7	58	0440-0450			
2350-2400	52	3.0	59	0450-0500			
0000-0010	50	2.7	57	0500-0510			
0010-0020	49	2.4	55	0510-0520			
0020-0030	52	3.3	61	0520-0530			
0030-0040	59	2.5	65	0530-0540			
0040-0050	49	2.6	55	0540-0550			
0050-0100	48	2.6	55	0550-0600			
0100-0110	49	2.6	55	0600-0610			
0110-0120				0610-0620			
0120-0130				0620-0630			
0130-0140				0630-0640			
0140-0150				0640-0650			
0150-0200				0650-0700			
0200-0210				0700-0710			
0210-0220				0710-0720			
0220-0230				0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B9

Room 21, De Noyan Block. June 16-17, 1976.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220	56	2.9	63	0310-0320			
2220-2230	55	3.4	64	0320-0330			
2230-2240	56	3.6	66	0330-0340			
2240-2250	56	3.7	65	0340-0350			
2250-2300	57	3.9	67	0350-0400			
2300-2310	58	3.7	67	0400-0410			
2310-2320	58	4.0	69	0410-0420			
2320-2330	58	3.8	67	0420-0430			
2330-2340	57	3.7	67	0430-0440			
2340-2350	57	3.9	68	0440-0450			
2350-2400	56	3.9	66	0450-0500			
0000-0010	56	3.7	65	0500-0510			
0010-0020	55	4.0	65	0510-0520			
0020-0030	55	3.9	65	0520-0530			
0030-0040	53	3.8	63	0530-0540			
0040-0050	53	3.7	62	0540-0550			
0050-0100	53	3.8	62	0550-0600			
0100-0110				0600-0610			
0110-0120				0610-0620			
0120-0130				0620-0630			
0130-0140				0630-0640			
0140-0150				0640-0650			
0150-0200				0650-0700			
0200-0210				0700-0710			
0210-0220				0710-0720			
0220-0230				0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

TABLE B10

Room 21, De Noyan Block. June 18-19, 1975.

	L_{eq}	σ	L_{NP}		L_{eq}	σ	L_{NP}
2200-2210				0300-0310			
2210-2220				0310-0320			
2220-2230				0320-0330			
2230-2240				0330-0340			
2240-2250				0340-0350			
2250-2300				0350-0400			
2300-2310	54	4.0	64	0400-0410			
2310-2320				0410-0420			
2320-2330	58	4.0	68	0420-0430			
2330-2340	55	4.2	66	0430-0440			
2340-2350	55	3.9	65	0440-0450			
2350-2400	55	4.5	66	0450-0500			
0000-0010	53	4.7	65	0500-0510			
0010-0020	52	4.2	63	0510-0520			
0020-0030	52	4.1	62	0520-0530			
0030-0040	52	4.5	64	0530-0540			
0040-0050	52	4.3	63	0540-0550			
0050-0100	52	4.4	63	0550-0600			
0100-0110	53	3.0	61	0600-0610			
0110-0120	53	2.8	60	0610-0620			
0120-0130	53	3.1	61	0620-0630			
0130-0140	55	1.6	60	0630-0640			
0140-0150	54	1.9	59	0640-0650			
0150-0200	53	2.8	60	0650-0700			
0200-0210	52	2.8	59	0700-0710			
0210-0220	54	1.6	58	0710-0720			
0220-0230	51	3.0	59	0720-0730			
0230-0240				0730-0740			
0240-0250				0740-0750			
0250-0300				0750-0800			

APPENDIX C

CLFCSC NOISE SURVEY

SC 7800-K73

7 May 76

Distribution List

NOISE SURVEY - FORT FRONTENAC

1. Since your arrival at Fort Frontenac a new Ferry service began operating from the foot of Barrack Street to the Wolfe Island - Marysville Landing.

2. As this Ferry and its associated traffic operates close to your quarters we would be interested in determining if this service causes a noise nuisance that interfers with your studies and/or rest. This survey is in conjunction with one being conducted by DCIEM.

3. Prior to your departure at the conclusion of the Course it would be appreciated if you would indicate on the bottom of this memorandum your comments as they pertain to:

a. Ferry operation - loading and unloading.

b. Vehicular noises - engines, horns etc.

c. Pedestrian noises.

d. Most common times and most annoying times.

4. This questionnaire can be returned to the Administration Office at your convenience.

W.H. Groom
Captain
for Commandant

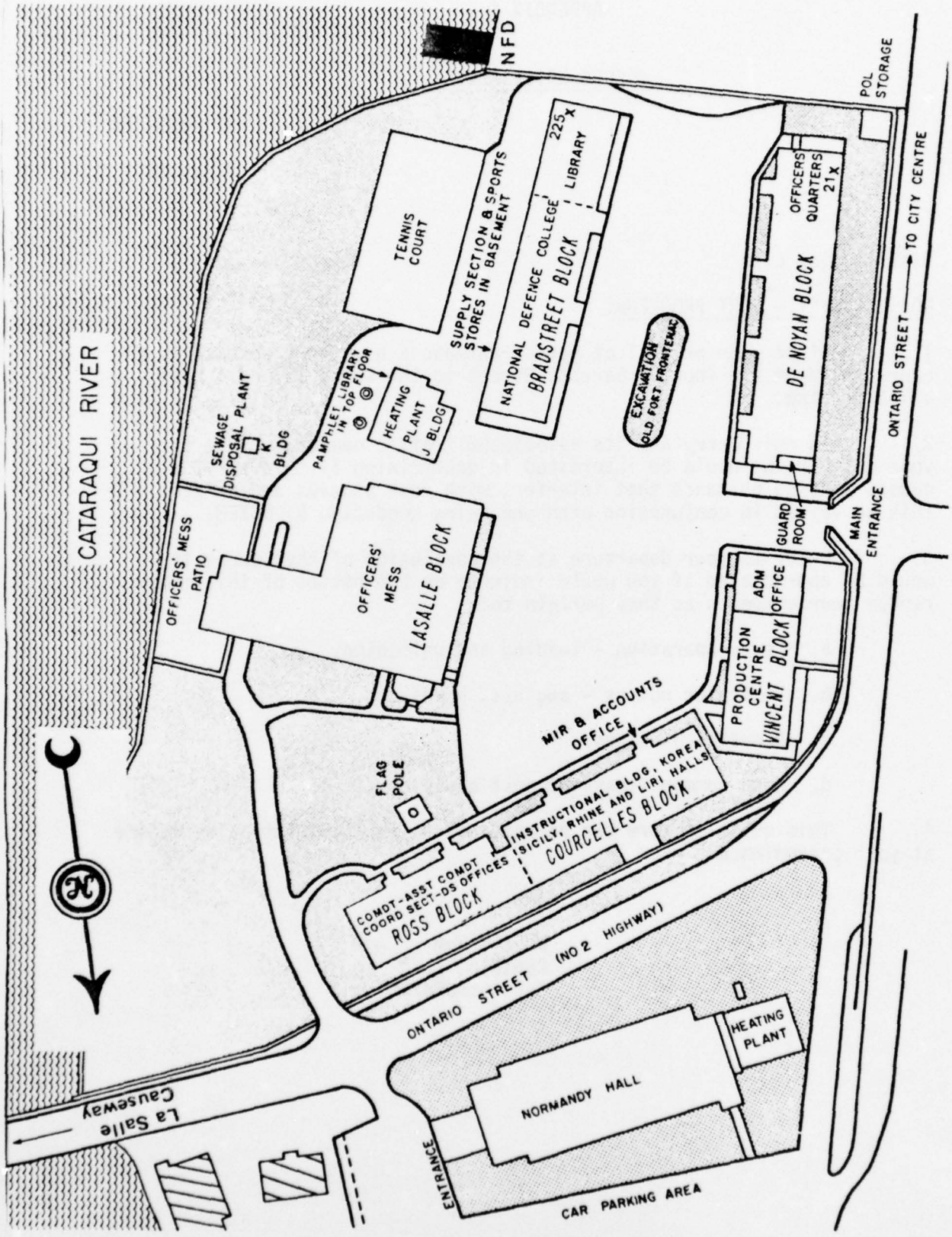

Figure 1. Plan of Fort Frontenac at Kingston, Ontario, home of the National Defence College and the Canadian Land Forces Command and Staff College.

Figure 2. View of Fort Frontenac from the south-west corner of Ontario and Barrack streets prior to construction of the new ferry dock and car-park area. In the foreground is the De Noyan Block (arrow indicates Room 21); in the background is the Bradstreet Block (arrow indicates Rooms 322 and 324).

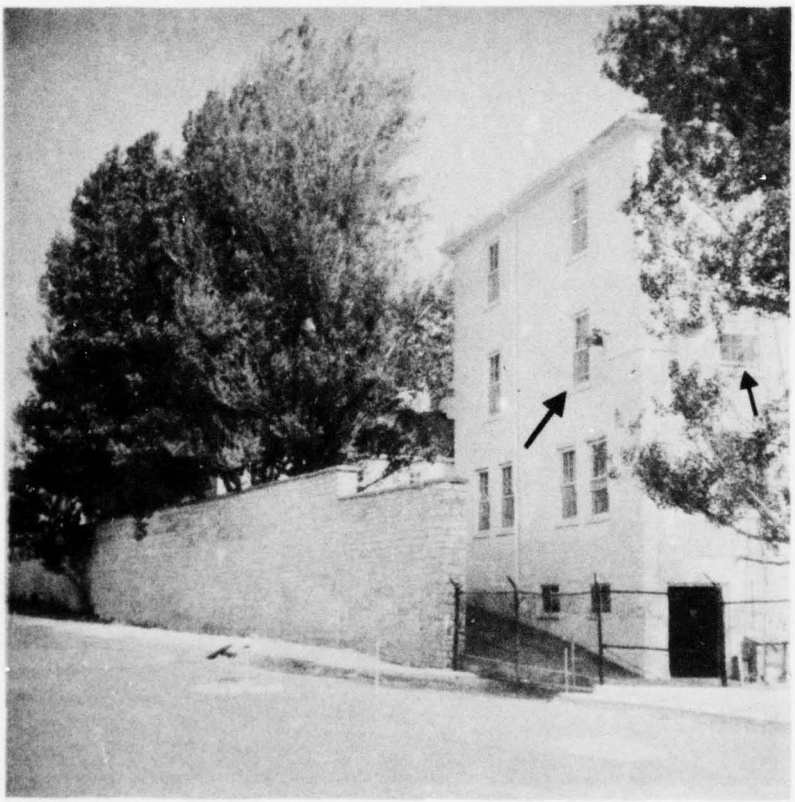

Figure 3. View of the south-east corner of Fort Frontenac prior to construction of the new ferry dock, showing the Bradstreet Block. Arrows indicate the south and east windows of Room 225.

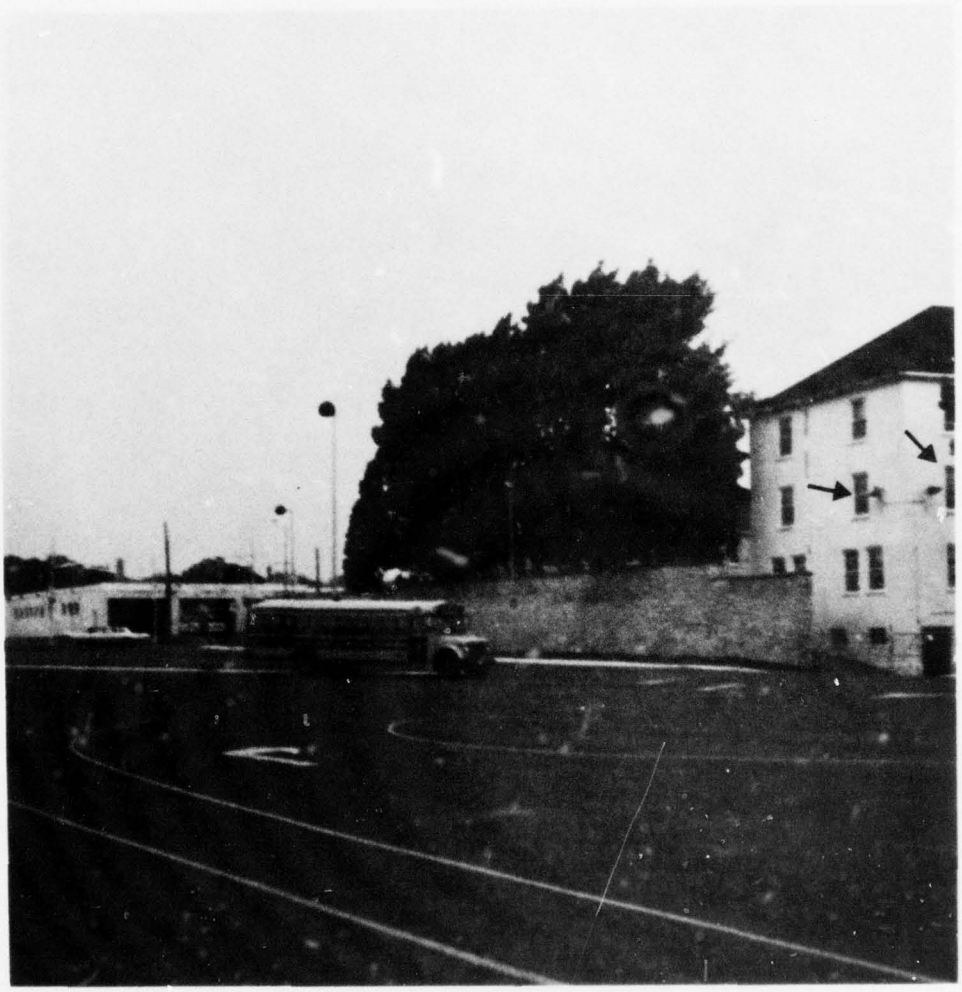

Figure 4. View of the south-east corner of Fort Frontenac after completion of the new ferry dock and car park area. Arrows indicate the south and east windows of Room 225 in the Bradstreet Block. The bus garages of the Kingston Public Transit System can be seen on the west side of Ontario Street.

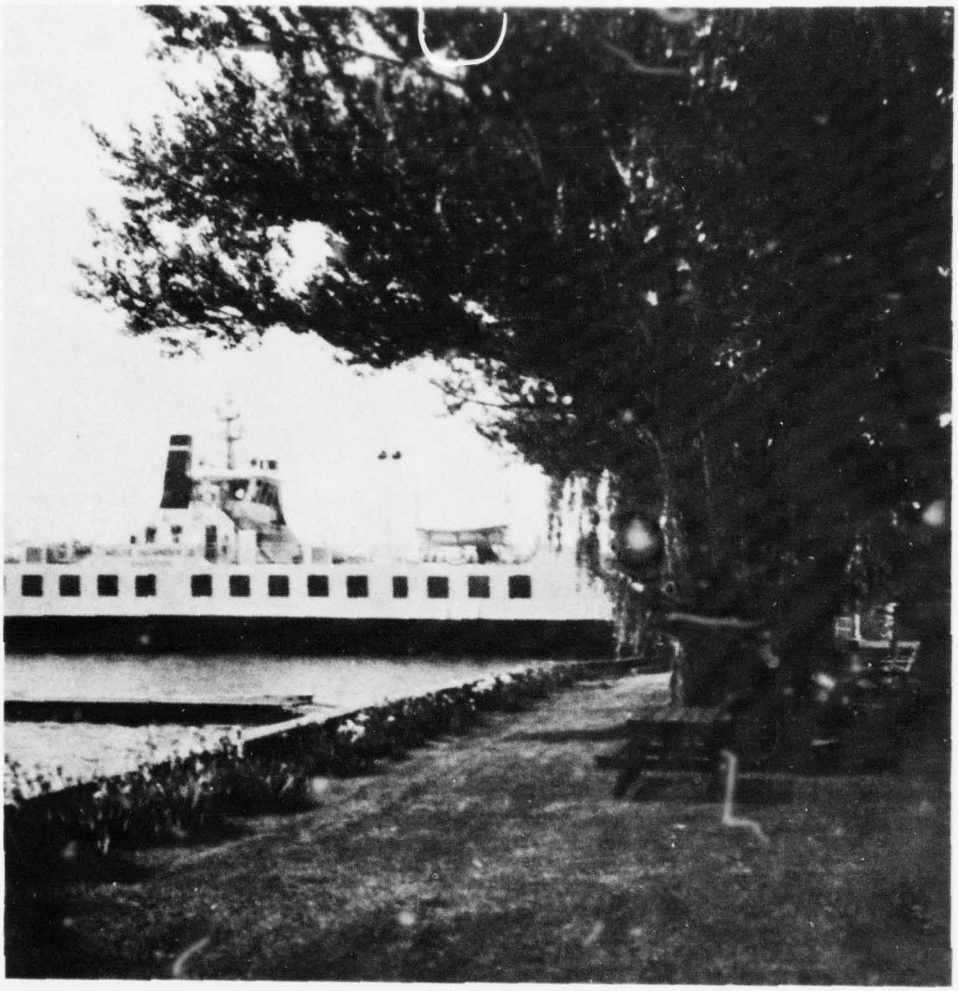

Figure 5. View of the Wolfe Island ferry berthed at the new ferry dock, taken from the lawn south of the Fort Frontenac Officer's Mess patio.

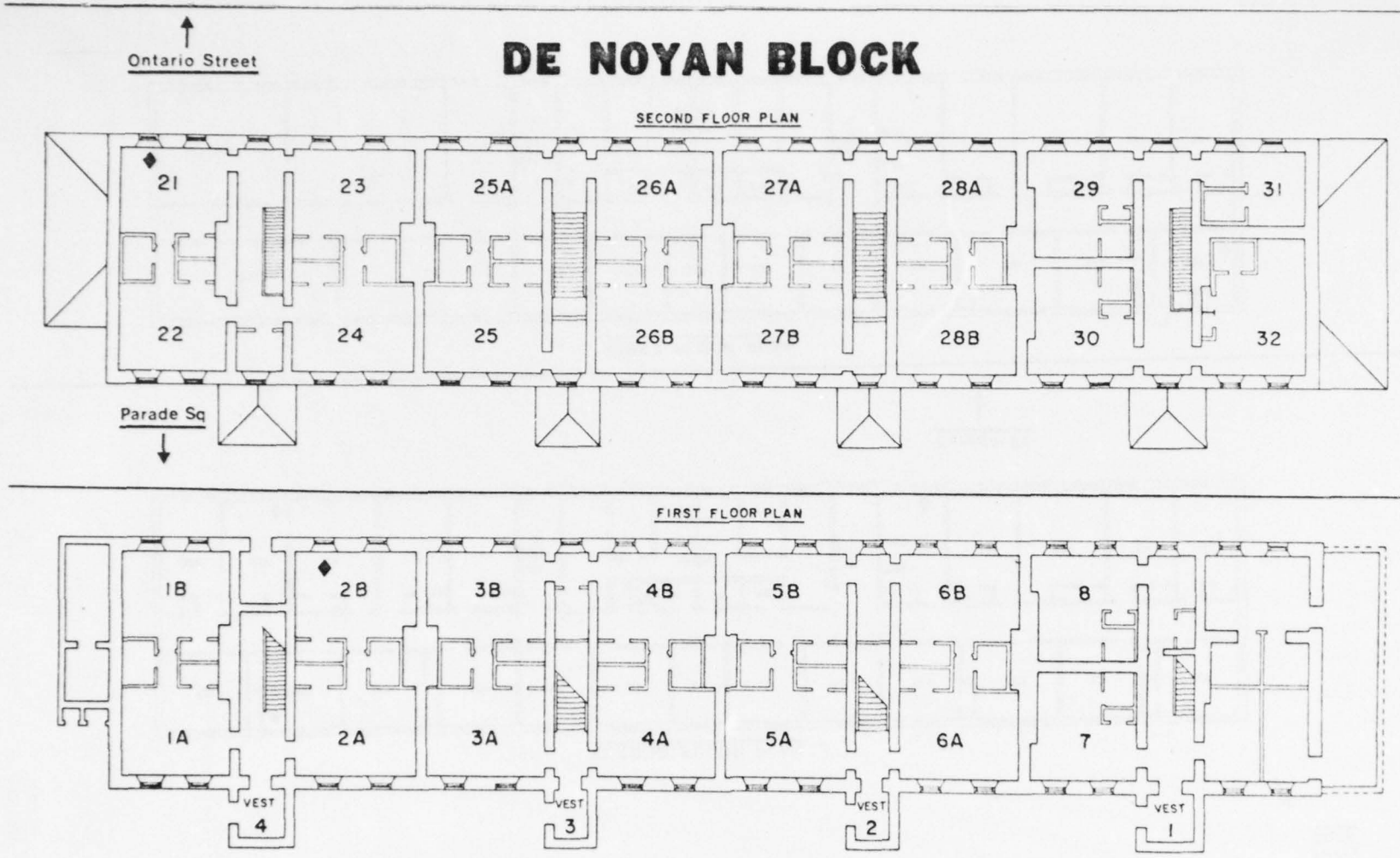

Figure 6. Plan of the De Noyan Block showing noise measurement locations in Rooms 2B and 21. The relative locations of Ontario Street and the parade square are also indicated.

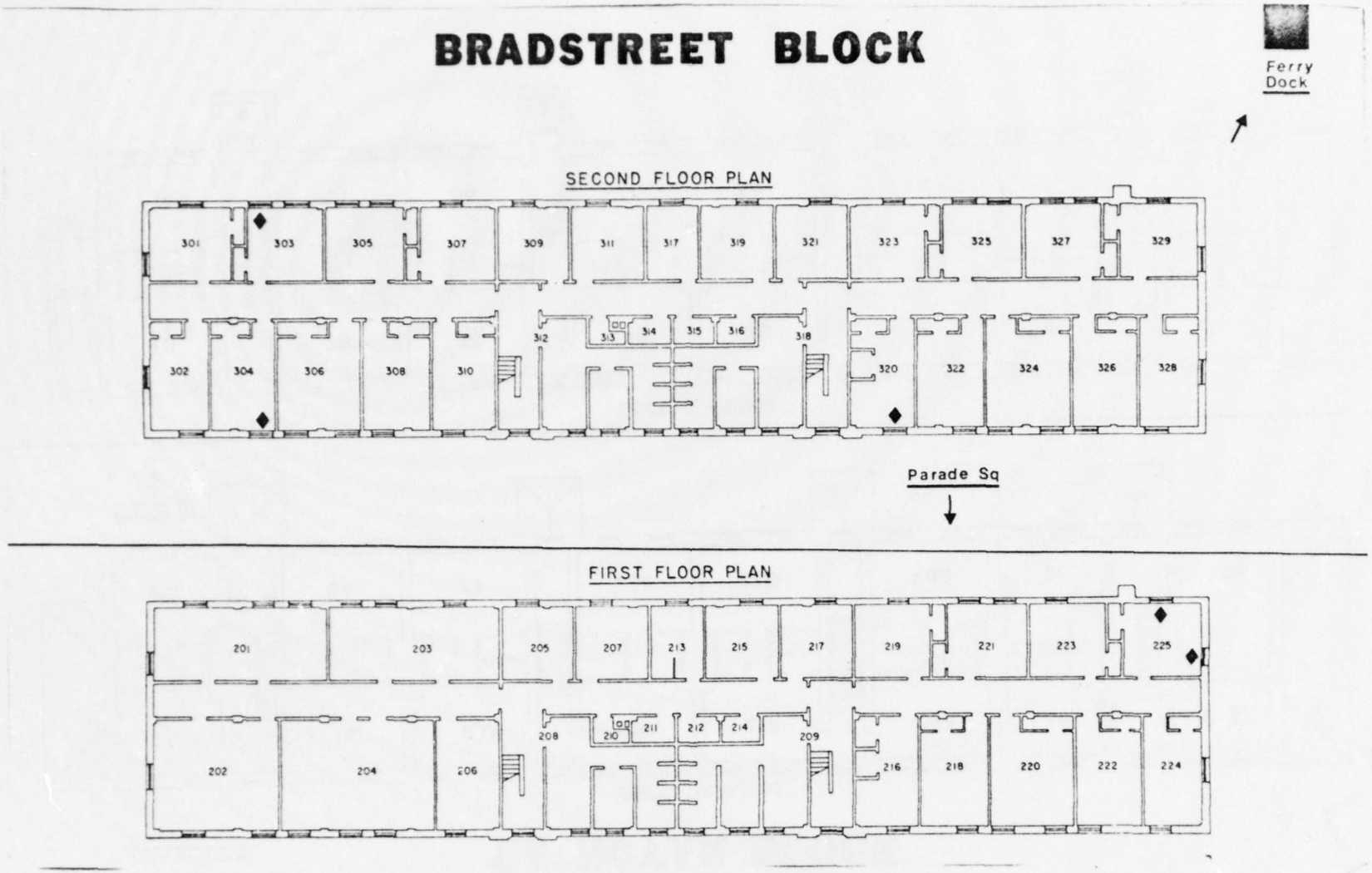

Figure 7. Plan of the Bradstreet Block showing noise measurement locations in Rooms 225, 303, 304 and 320. The relative locations of the new ferry dock and the parade square are also indicated.

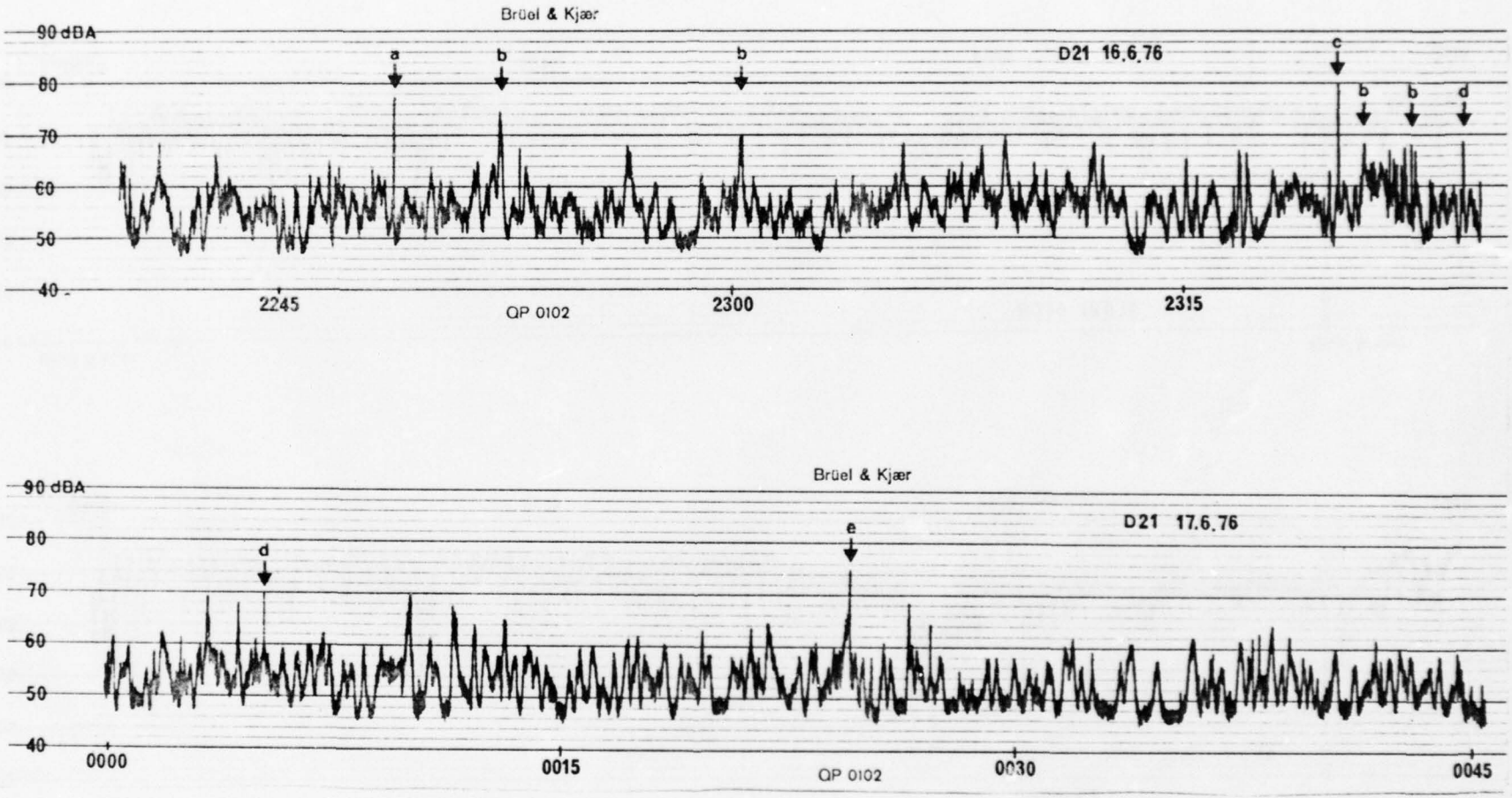

Figure 8. Graphical time history of ambient noise levels, in dBA, recorded in the window of Room 21, De Noyan Block, (1) on 16 June 1976 between 2240 and 2325 hours and (2) on 17 June 1976 between 0000 and 0045 hours. The labeled noise peaks were produced by screeching car tires, (b) heavy truck or bus engine noise, (c) car-ferry horn, (d) automobile horns, and (3) motor cycles.

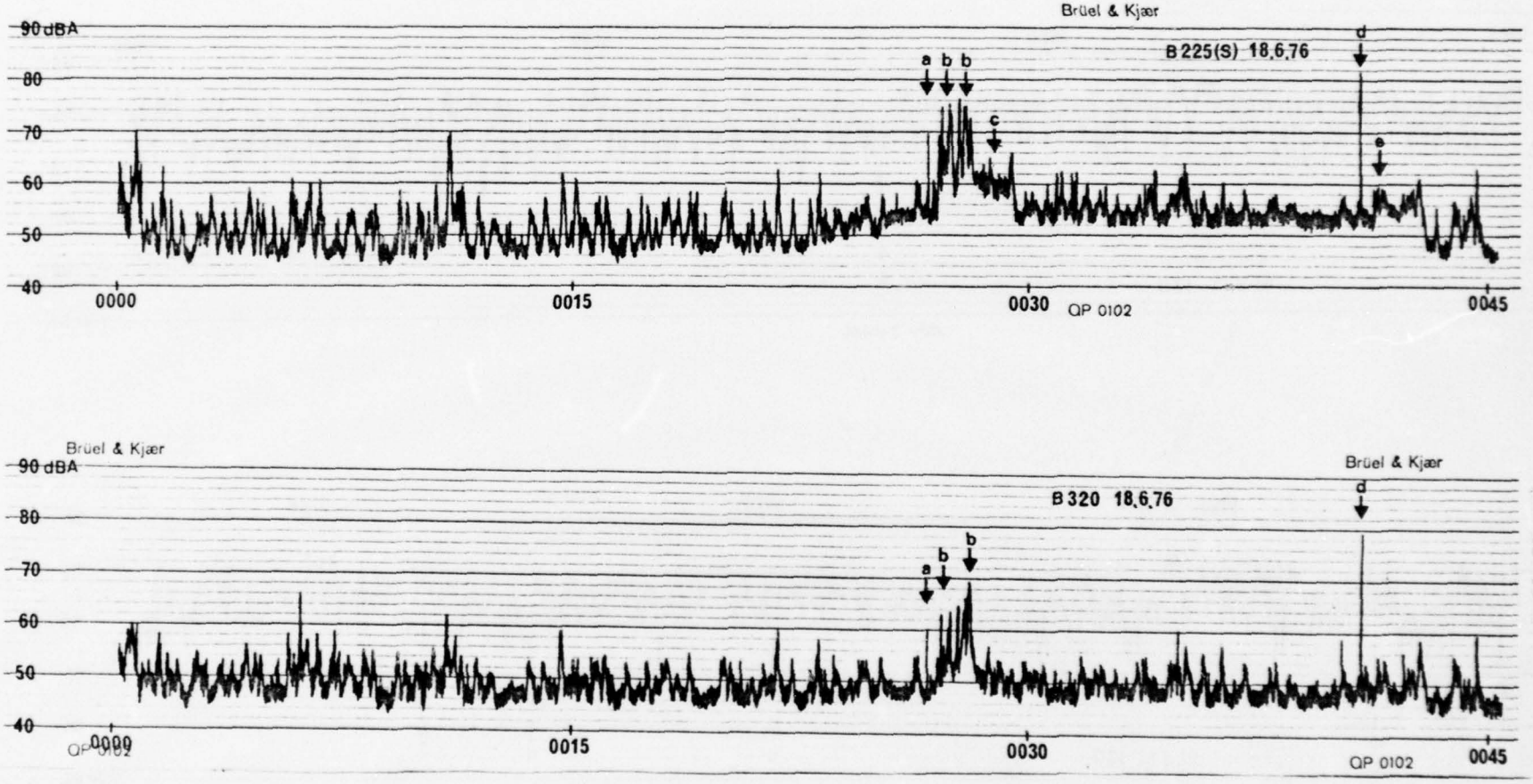

Figure 9. Graphical time history of ambient noise levels, in dBA, recorded (1) in the south window of Room 225 and (2) in the window of Room 320, both in the Bradstreet Block, in 18 June 1976 between 0000 and 0045 hours. The labeled noise peaks were produced by (a) car-ferry ramp dropping, (b) vehicle horns on the ferry dock, (c) truck engine idling, (d) car-ferry horn, and (e) engines of car-ferry underway.

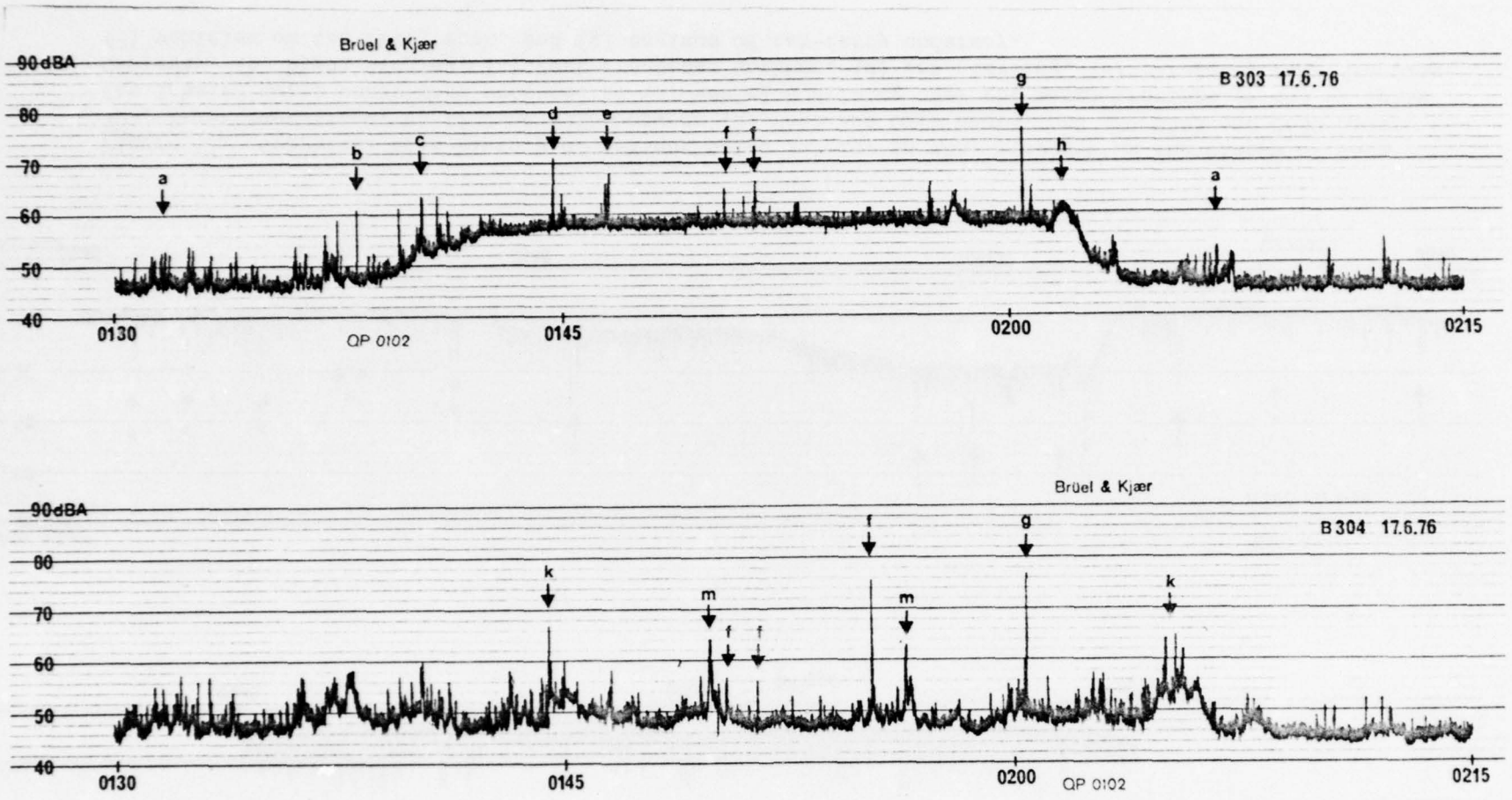

Figure 10. Graphical time history of ambient noise levels, in dBA recorded in the windows of (1) Room 303 and (2) Room 304, both in the Bradstreet Block, on 17 June 1976 between 0130 and 0215 hours. The labeled noise peaks were produced by (a) vehicles driving over the metal gratings on the La Salle Causeway, (b) louspeaker on the ferry dock, (c) general activity on the ferry dock as the ferry arrives, (d) car-ferry ramp dropping, (e) vehicle horns on the ferry dock, (f) screeching car tires, (g) car-ferry horn, (h) engines of car-ferry underway, (k) car starting in Fort Frontenac parade square, and (m) vehicles on Ontario Street.

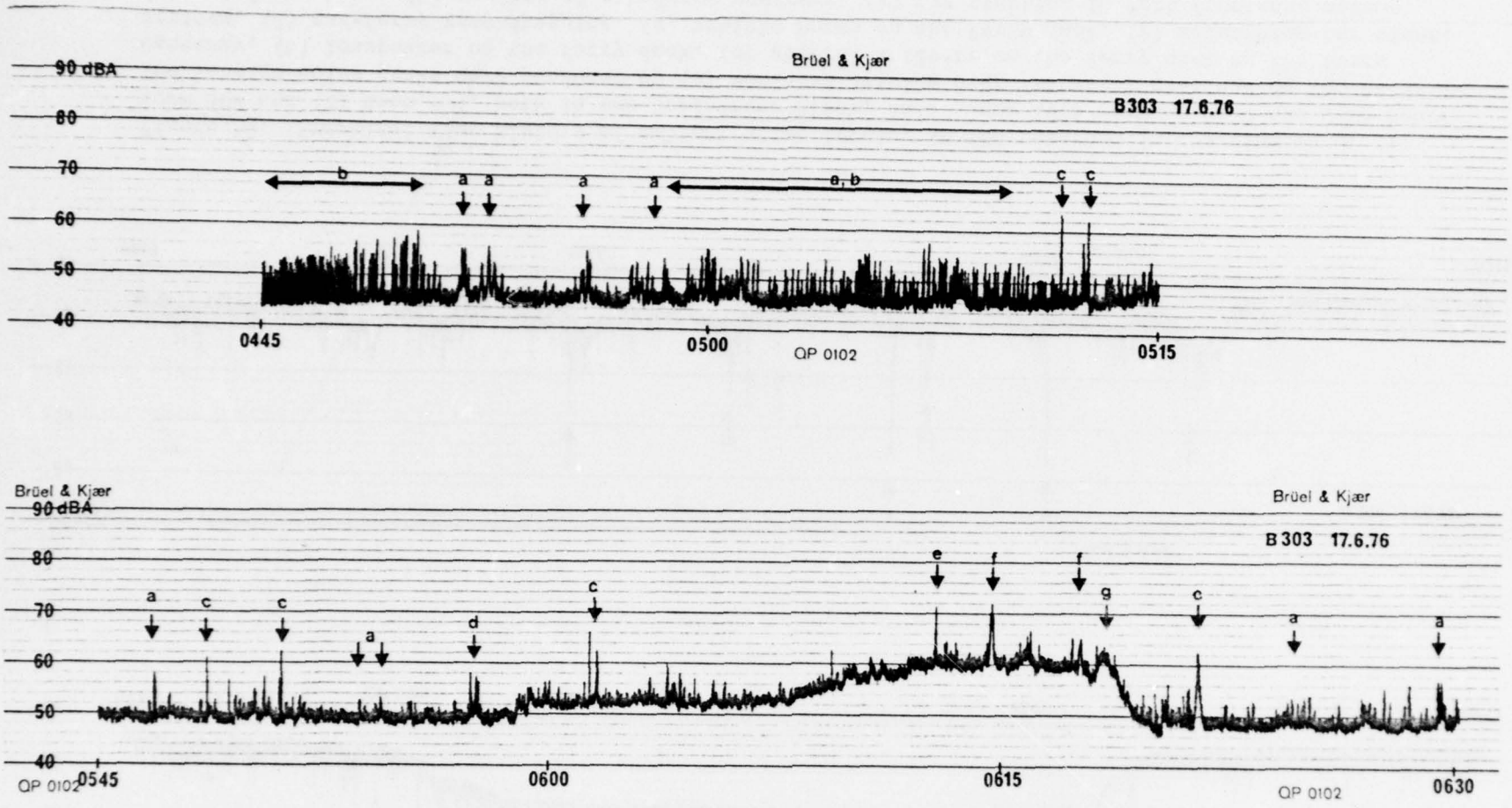

Figure 11. Graphical time history of ambient noise levels, in dBA, recorded in the window of Room 303, Bradstreet Block, on 17 June 1976 between (1) 0445 and 0515 hours, and (2) 0545 and 0630 hours. The labeled noise peaks were produced by (a) vehicles driving over the metal gratings on the La Salle Causeway, (b) birds singing, (c) Fort Frontenac workmen, (d) car starting, (e) car-ferry ramp dropping, (f) vehicles on the ferry dock, and (g) engines of car-ferry underway.

Figure 12. View of the Fort Frontenac Officer's Mess patio and beyond, the La Salle Causeway.

Figure 13. View of loading ramp on the new ferry dock.

Figure 14. Truck disembarking from the Wolfe Island ferry.

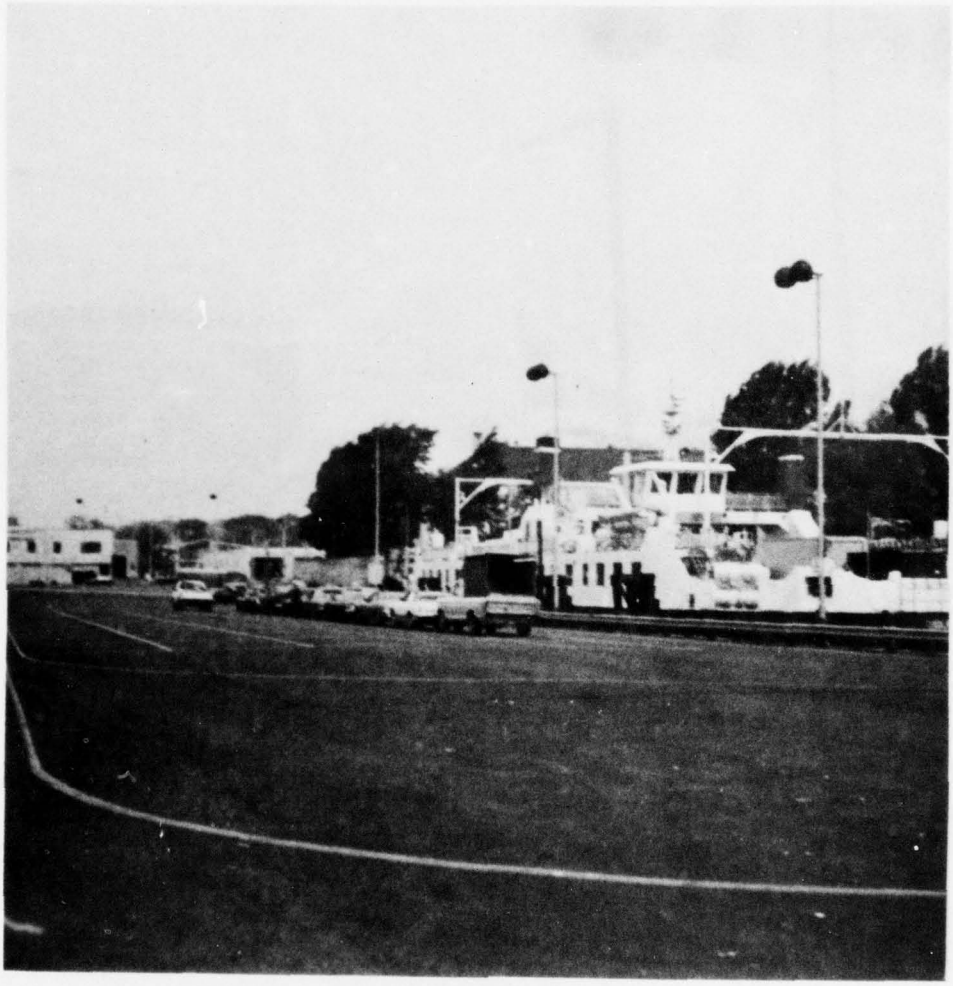

Figure 15. View of the Wolfe Island ferry berthed at the new ferry dock. Vehicles in the parking area are waiting to embark and procede to Wolfe Island.

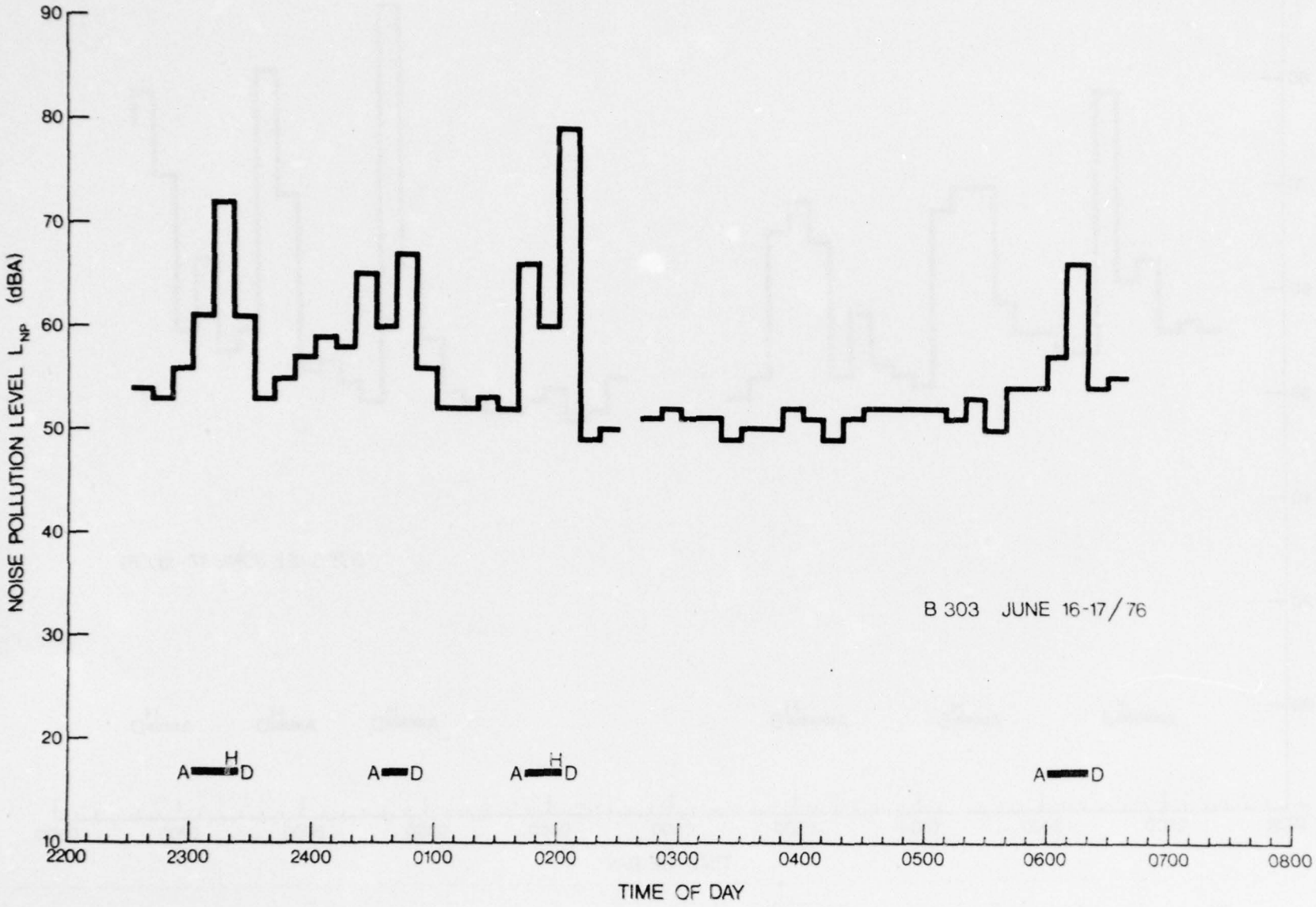

Figure 16. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 303 in the Bradstreet Block during the night of June 16-17th, 1976. The corresponding values of L_{eq} and σ are listed in Table B1, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

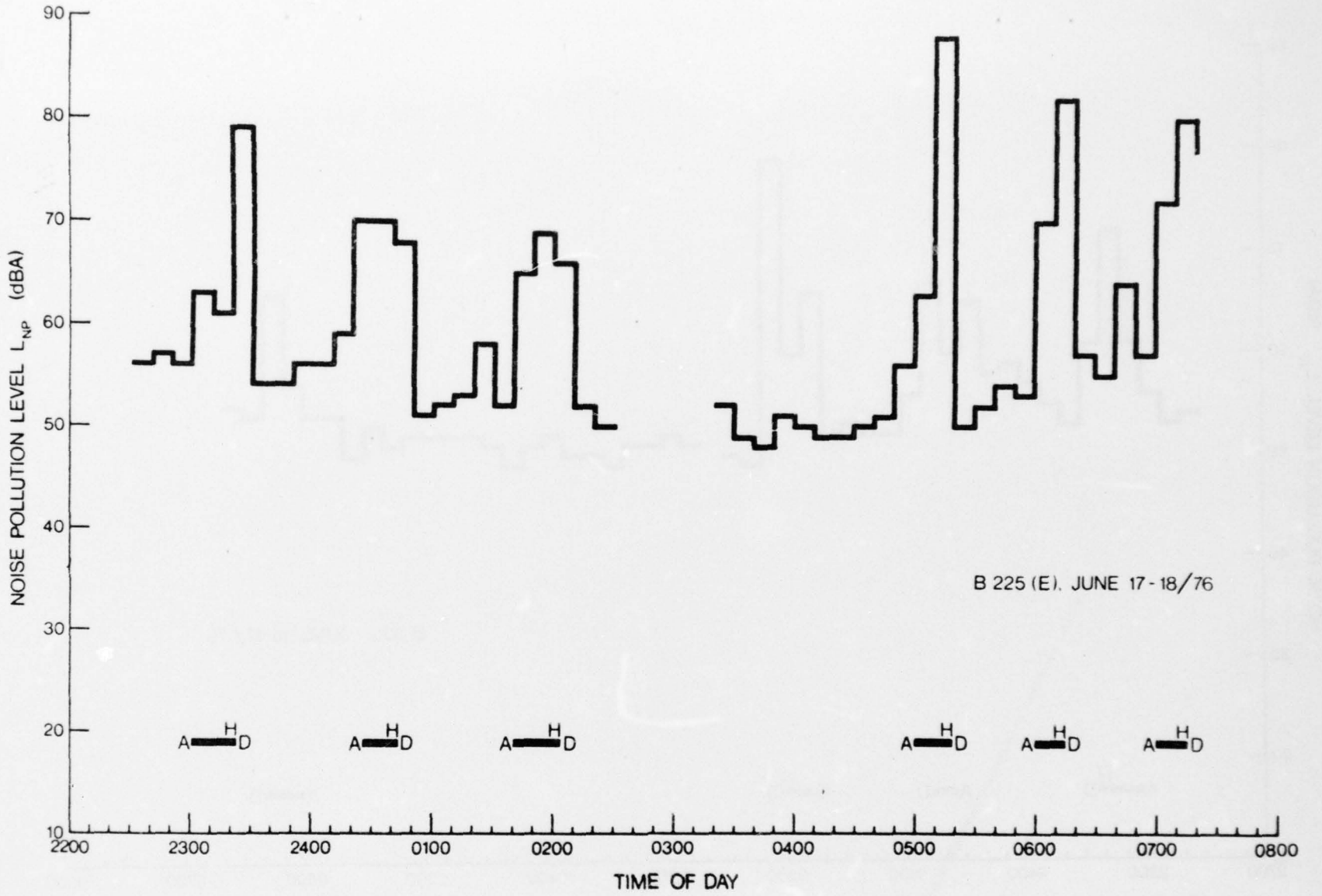

Figure 17. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the east window of Room 225 in the Bradstreet Block during the night of June 17-18th, 1976. The corresponding values of L_{eq} and σ are listed in Table B2, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

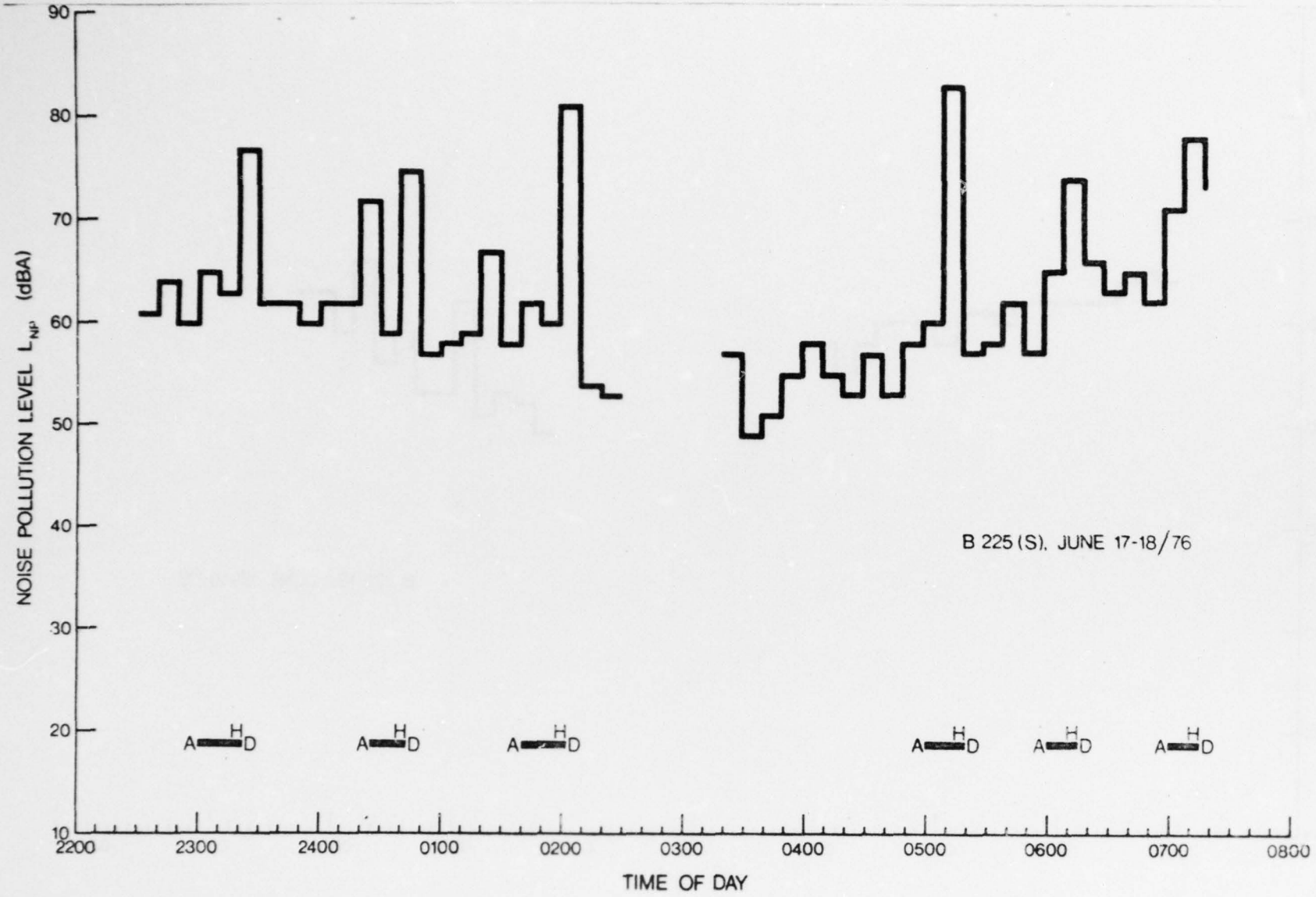

Figure 18. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the south window of Room 225 in the Bradstreet Block during the night of June 17-18th, 1976. The corresponding values of L_{eq} and σ are listed in Table B3, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

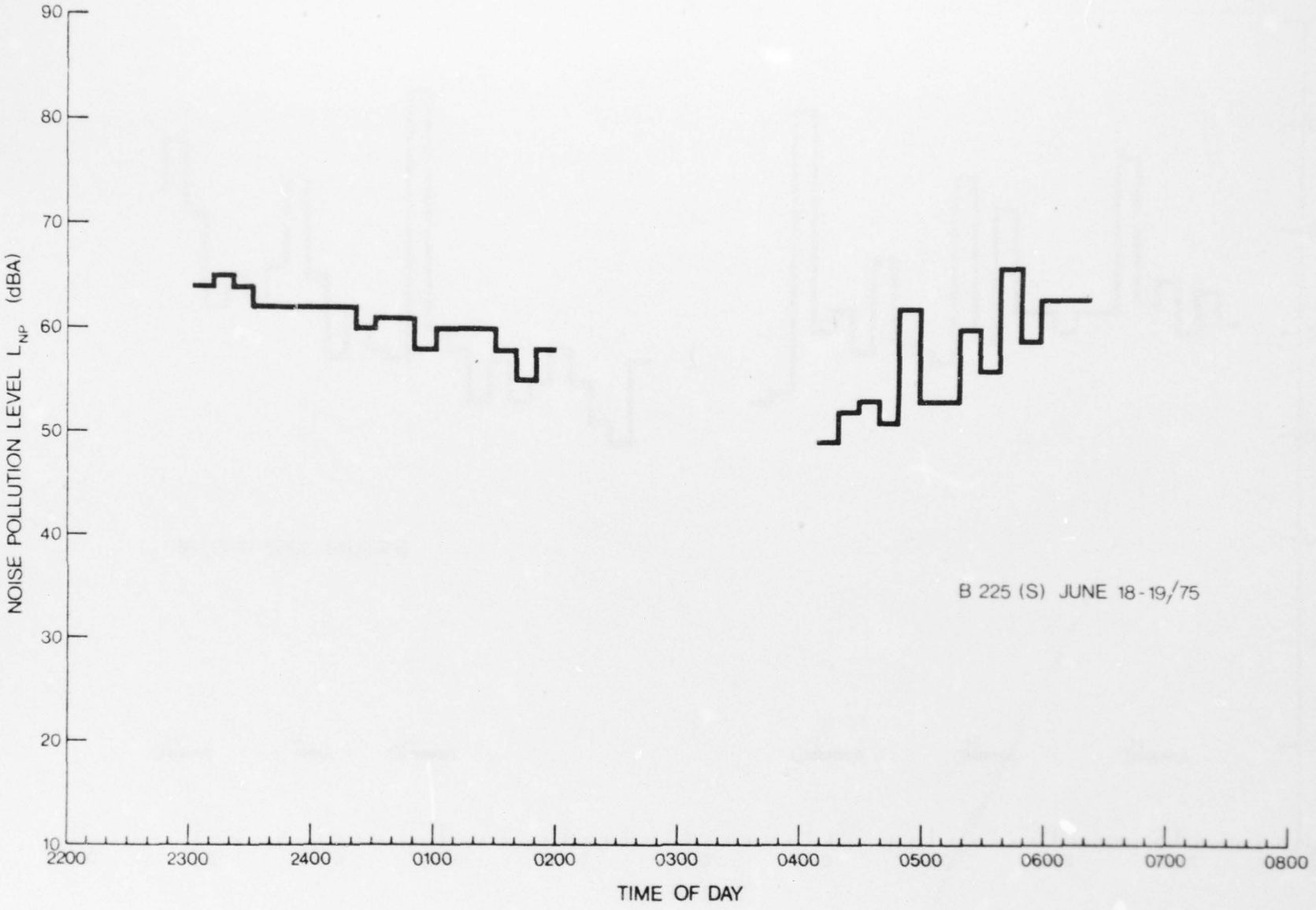

Figure 19. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the south window of Room 225 in the Bradstreet Block during the night of June 18-19th, 1975. The corresponding values of L_{eq} and σ are listed in Table B4 , Appendix B.

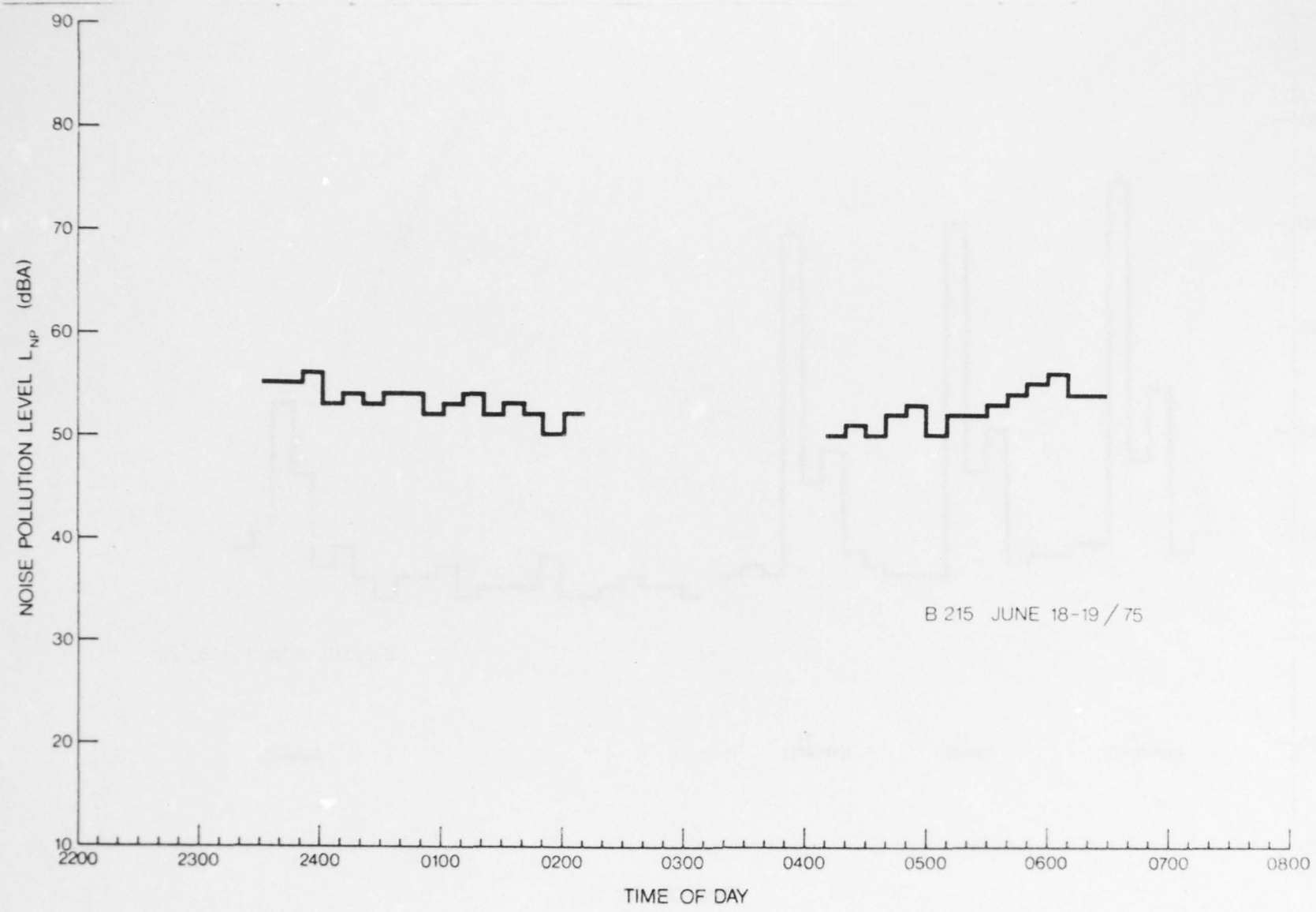

Figure 20. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 215 in the Bradstreet Block during the night of June 18-19th, 1975. The corresponding values of L_{eq} and σ are listed in Table B5.

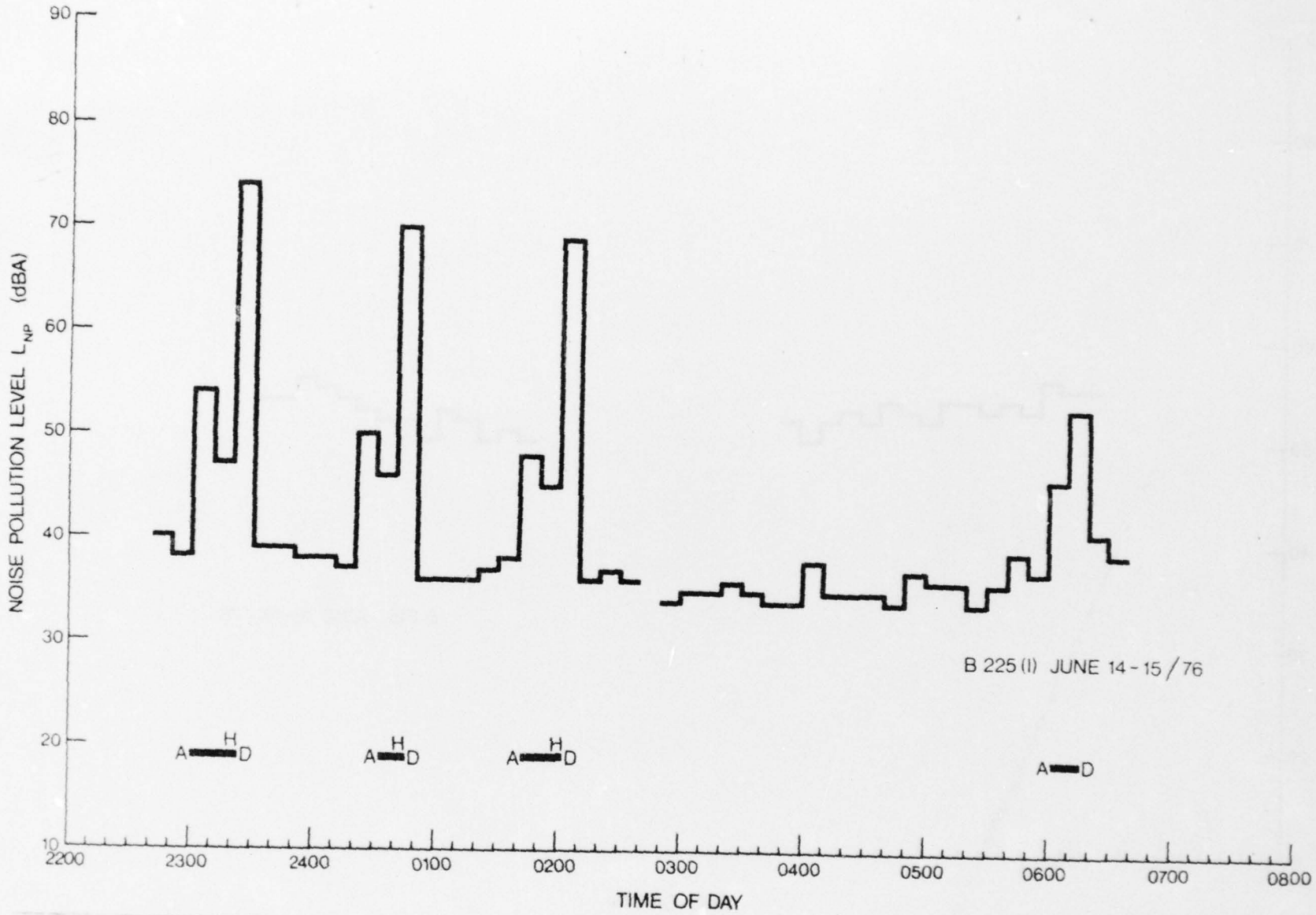

Figure 21. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed inside Room 225 (with the east window open) in the Bradstreet Block during the night of June 14-15th, 1976. The corresponding values of L_{eq} and σ are listed in Table B6, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

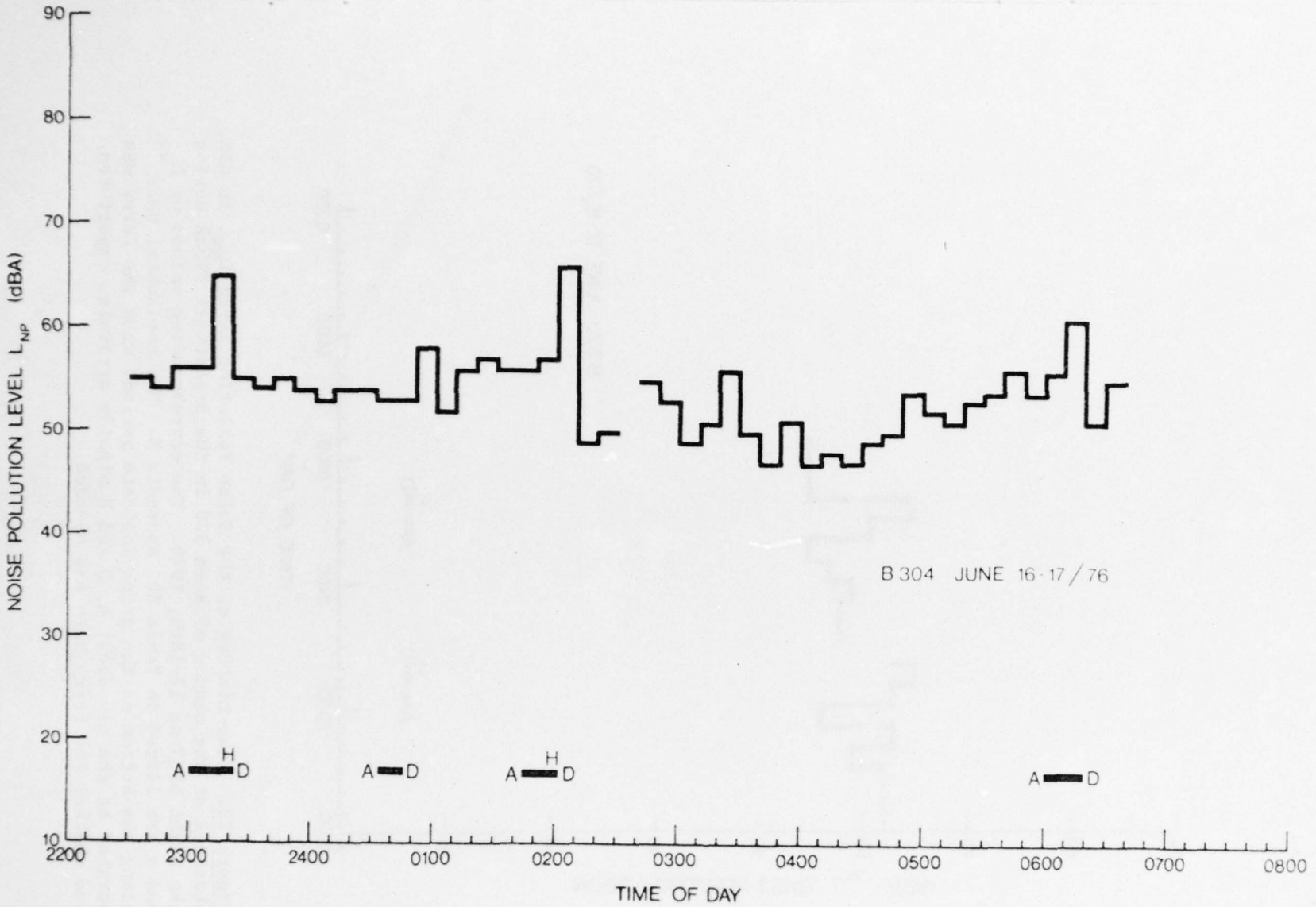

Figure 22. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 304 in the Bradstreet Block during the night of June 16-17th, 1976. The corresponding values of L_{eq} and σ are listed in Table B7, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

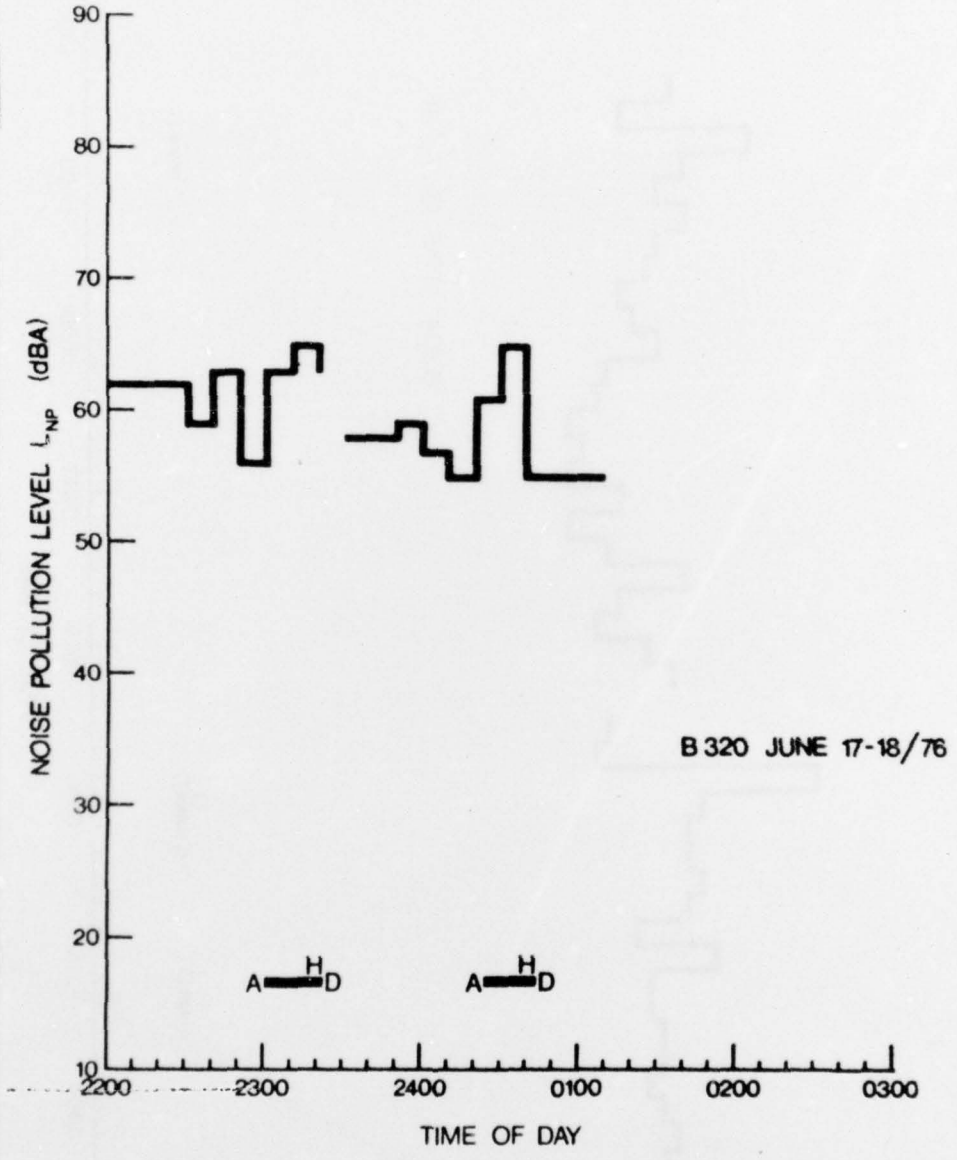

Figure 23. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 320 in the Bradstreet Block during the night of June 17-18th, 1976. The corresponding values of L_{eq} and σ are listed in Table B8, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

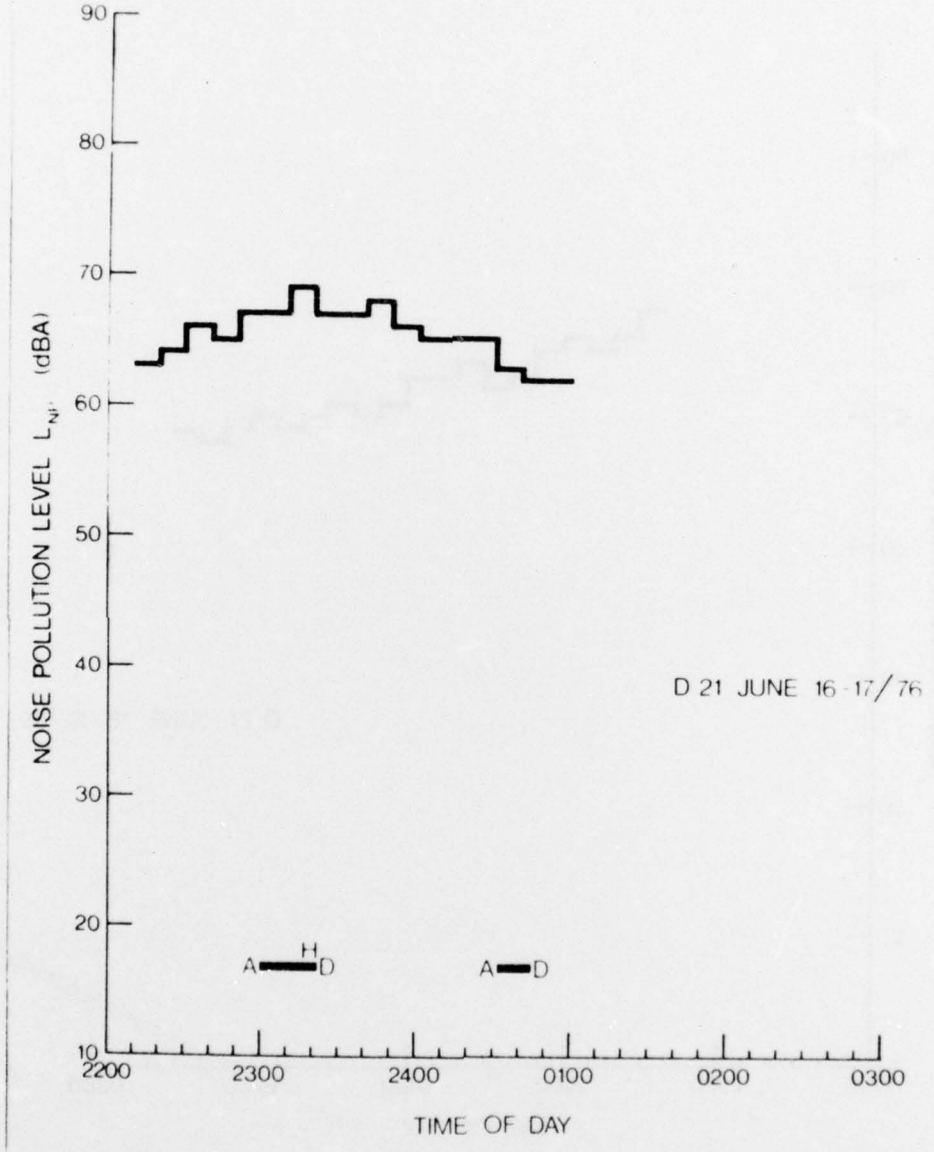

Figure 24. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 21 in the De Noyan Block during the night of June 16-17th, 1976. The corresponding values of L_{eq} and σ are listed in Table B9, Appendix B. The horizontal bars along the bottom of the graph indicate periods when the ferry was berthed at the new dock; A, D and H signify arrivals, departures, and whether the ferry horn was sounded.

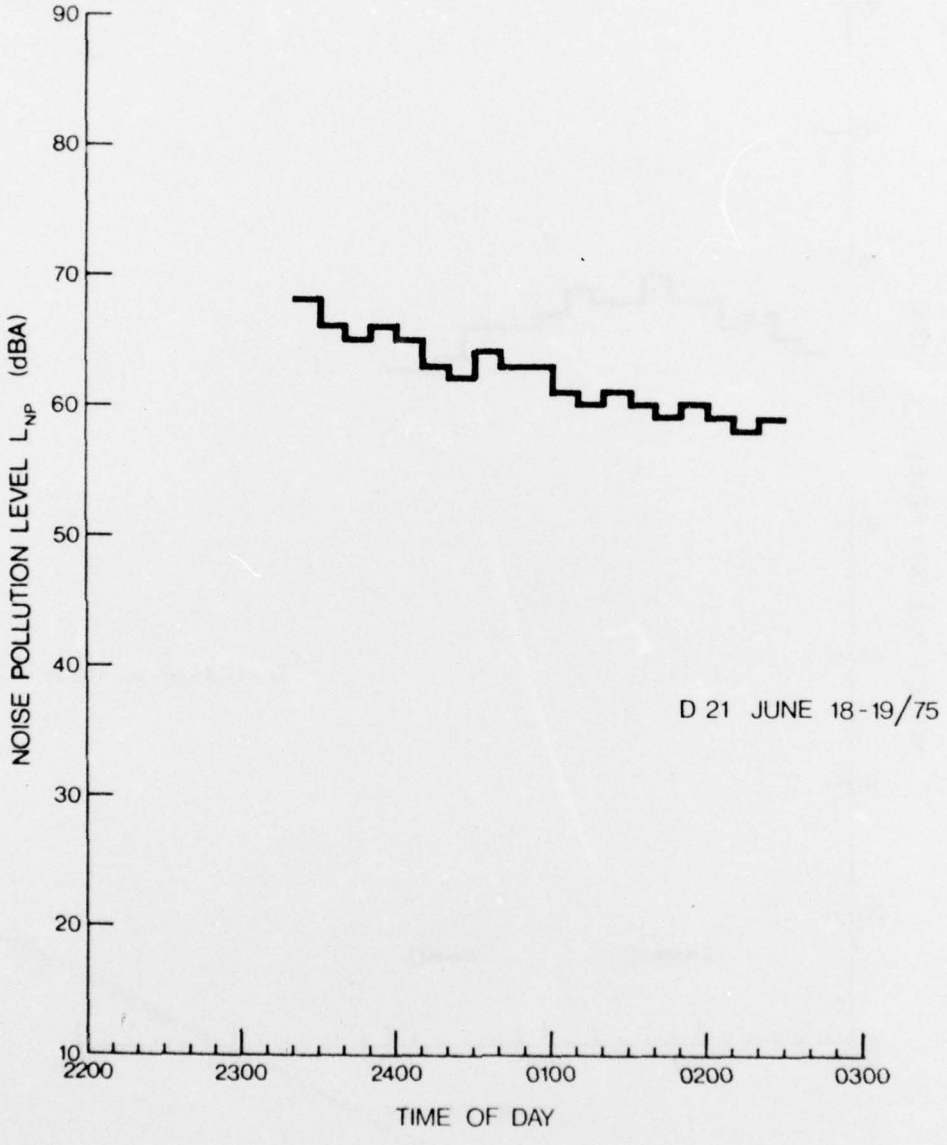

Figure 25. Time-history of the Noise Pollution Level L_{NP}, in dBA, observed at the window of Room 21 in the De Noyan Block during the night of June 18-19th, 1975. The corresponding values of L_{eq} and σ are listed in Table B10, Appendix B.

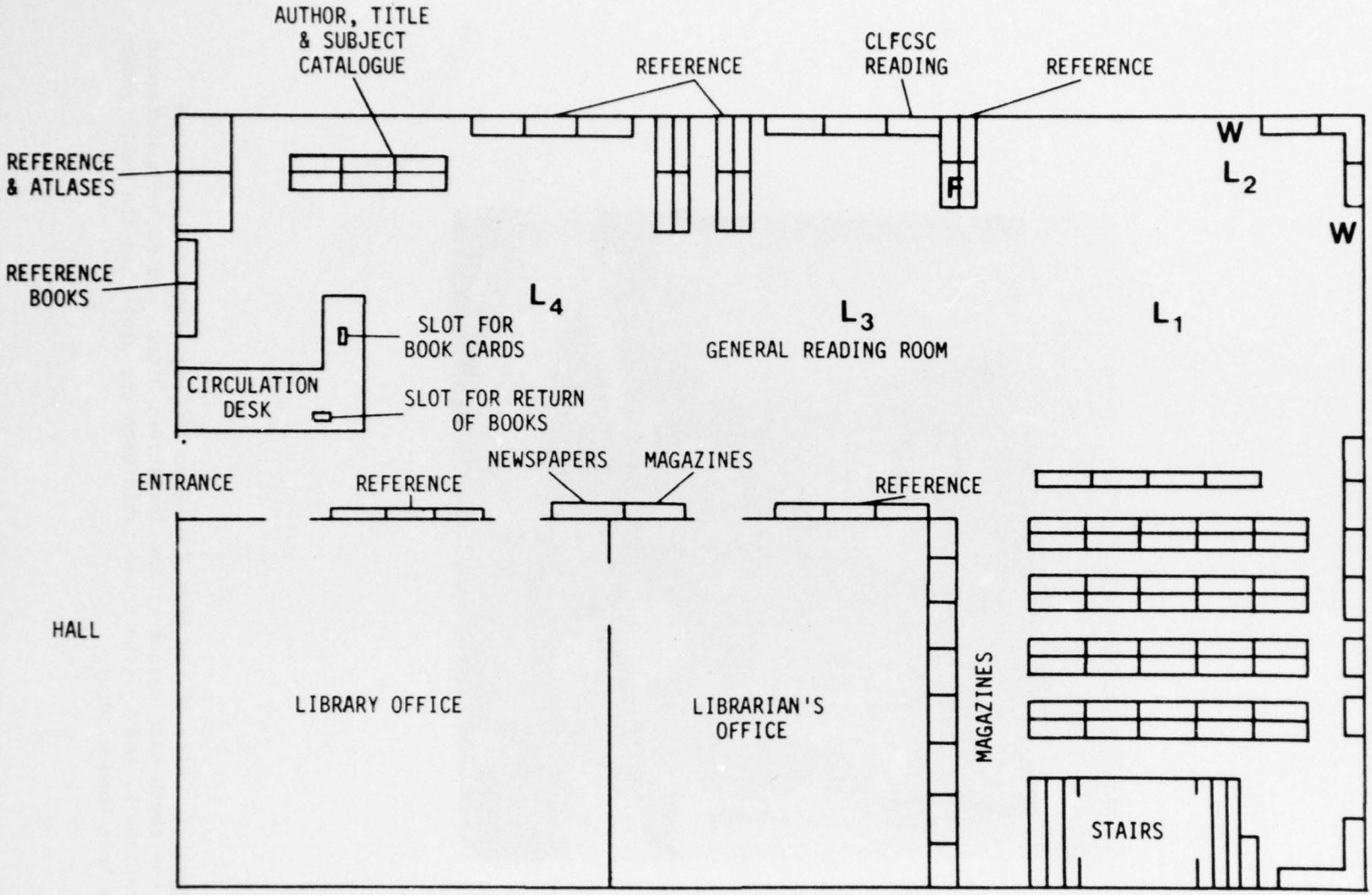

Figure 26. Plan of the ground-floor area of the Fort Frontenac Library, showing noise-measurement locations L_1, L_2, L_3 and L_4. The locations of windows on the south-east corner of the Bradstreet Block and the fan used to circulate air in the general reading area are indicated by W and F.

Figure 27. View of the Fort Frontenac Library showing the windows on the south-east corner of the Bradstreet Block, and noise-measurement locations L_1 and L_2 (the round table with the globe and the table under the left-hand window).

Figure 28. View of the Fort Frontenac Library showing the general reading area and the fan used to circulate air.

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13. ABSTRACT

This report presents the results of an investigation conducted at Kingston, Ontario to determine the effect of a new car-ferry service upon ambient noise levels in the two Canadian Forces Colleges housed in nearby Fort Frontenac.

By means of questionnaires and computed Noise Pollution Levels, it was concluded that annoyance and sleep disturbance were a problem in quarters close to the ferry dock.

It is recommended that the ferry should not sound its horn prior to departure from its dock next to Fort Frontenac. This, alone, would eliminate the most serious source of annoyance and disturbance. Also, the Fort Frontenac Library, and rooms in the Bradstreet Block with windows facing east and south, should be fitted with sealed, double-glazed, noise-attenuating windows, and be equipped with air-conditioning.

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Noise Annoyance

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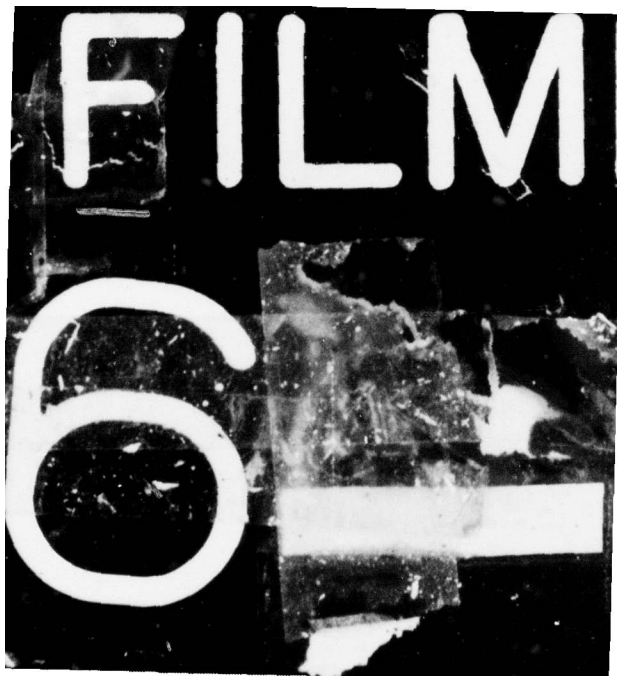
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